MARCH 1940

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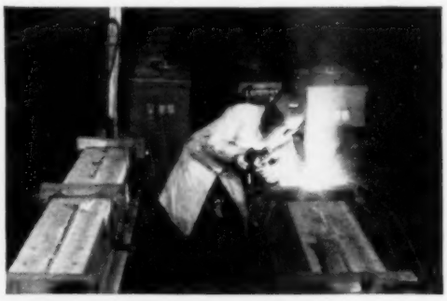
# The WELDING Journal

The Journal of the American Welding Society

# Why Not *Take a Tip* from These Fabricators? *Switch to* A-c Welding and SAVE



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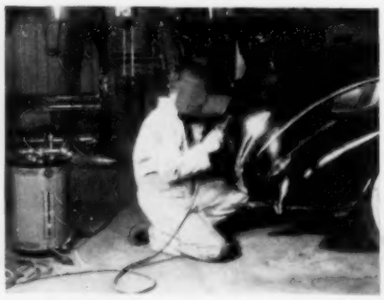

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# The American Welding Society Journal

W. SPRARAGEN, Editor

**Published for the Advancement of the Science and Art of Welding**

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All-Welded Diesel Propelled Tug.
*Photo courtesy The Pusey & Jones Corporation.*

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Welding Journal

VOLUME 19, No. 3 MARCH 1940

# USE OF STEEL CASTINGS AND Rolled Steel Plate in Welded Fabrication*

By H. J. SHIFFLI† and E. L. KREJCI‡

## INTRODUCTION

MUCH has been said and written on the subject of steel castings and welded structures. Most of us are familiar with the history and fundamental principles governing the production of both products. Practically all the detailed information has been well covered during the past decade. The purpose of this paper will be confined to the "Use of Steel Castings and Rolled Steel Plate in Welded Fabrication."

## PURPOSE

One of the chief advantages of welded construction is that it allows the designer to use in combination a variety of shapes and types of steel to produce the best design at a minimum cost. He has his choice of standard shapes such as plates, sheets, billets, bars, beams, angles, channels, tubing, stampings, forgings and steel castings. What this choice will be is in many cases a matter of opinion. However, mere opinion should not be the determining factor. A few years ago welding enthusiasts used as their slogan—"If it's steel, weld it; if it's cast, change it!" No doubt many engineers interpreted this statement literally. The result was that many machinery parts and miscellaneous structures were totally welded without any regard to their cost. Quite naturally this condition existed during a period which is commonly known as a seller's market. Consequently, the engineer could allow his imagination to run wild because there was a demand for his creations. Today, we are in the midst of a buyer's market. Woe to the engineer who fails to consider the size of purse of the prospective purchaser, for surely he shall feel the heavy hand of competition.

* Presented at Annual Meeting, A. W. S., Chicago, Oct. 23 to 27, 1939.
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‡ Works Manager, Hammond Works, American Steel Foundries, Hammond, Indiana.

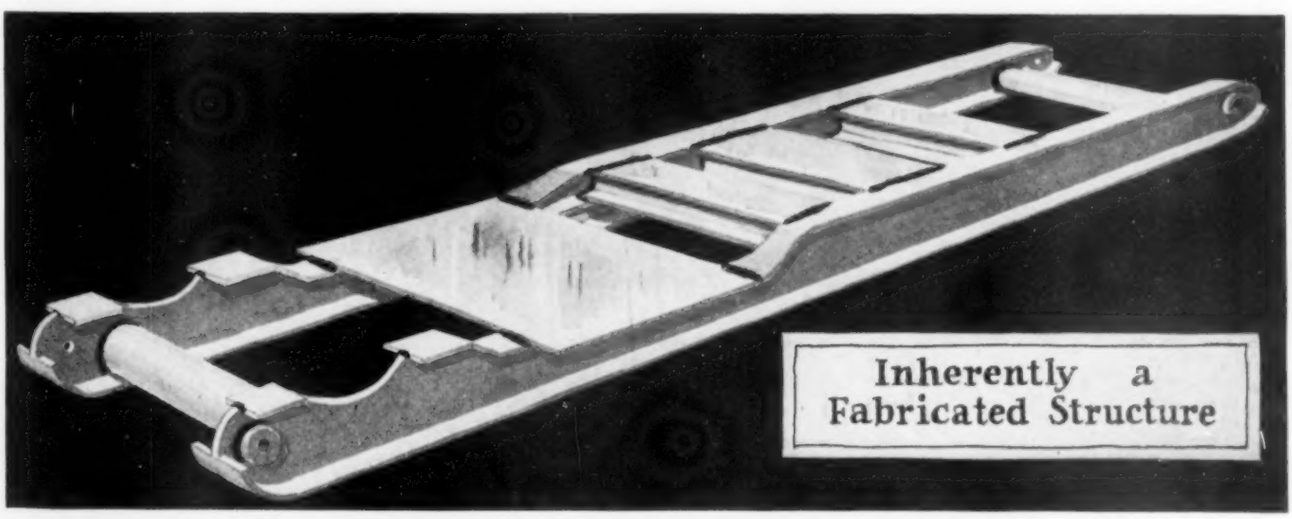



Fig. 1—Frame 20 Feet Long 80 Inch Max. Width Sides Are 15-Inch I Beams. Most of the Plate Is 1/2 Inch, 9-Inch Tubing, 6-Inch Cross I Beams, Weight 2600 Lb.

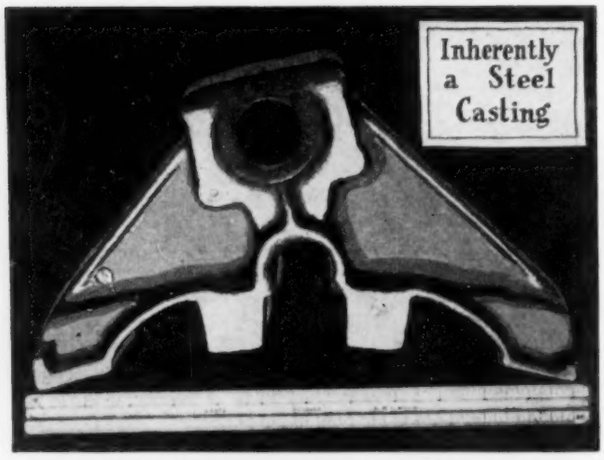



Fig. 2—Railroad Equipment Brakehead Weight 12 Lb.

## WHEN AND WHERE TO USE CASTINGS

The scope of the welding art, in its application of steel castings as integral parts of welded structures and the number and variety of the examples to be found, has no limit within any reasonable bounds. A study was made of several hundred cases wherein the "when, where, why and how" of using steel castings in welded fabrication was carefully analyzed.

When a particular part of a fabricated structure is intricate and does not lend itself to simplification by the use of standard shapes and forms, the designer should consider a steel casting. The statement that no such conditions exist is obviously absurd. Hundreds of examples prove this. When the physical dimensions of a certain section of a structure are compact to the extent that the welding operation cannot be performed satisfactorily, here again a steel casting will prove successful. Often fabricated machinery parts will require from four to eight similar bearing housings. In such cases steel castings are generally well adapted. When the number of separate pieces involved and the number of feet of welding required throw the direct labor out of proportion to the remainder of the structure, a steel casting always justifies itself. If costly dies are required to form special shapes and the quantity required does not justify the cost of the dies, invariably a steel casting will result in marked economy. When the number of pieces required is so numerous that it complicates the jigs and fixtures which are necessary in quantity production, a steel casting can and will simplify the jig and fixture problem and reduce the cost. In cases where a few constructions of a particular design require the use of steel of a special composition or alloy in certain of its parts, such alloyed parts can be of cast steel and welded to the balance of the structure.

Thus we note that intricacy, compactness, quantity, direct labor, costly equipment and varied materials are deciding factors in determining "when and where" to use steel castings in welded fabrications.

## WHY USE CASTINGS

The "why" in the use of steel castings in fabricated structures centers mostly around cost and judgment. Patterns are a necessary part of the equipment for producing steel castings and when castings are made in very limited quantities the pattern charge adds materially to their unit cost. But when the pattern charge is spread over a larger number of such castings, it becomes greatly reduced, per unit, and is considered eventually to be absorbed. Welded jobs require jigs and fixtures of more or less elaboration according to the nature of the work. Sometimes these jigs and fixtures become a very expensive item compared to which the pattern cost incident to steel castings is of less importance than frequently supposed.

As we have previously mentioned, the method to be used in producing details of mechanical construction is determined by the cost. It must be if competition is satisfactorily to be met. If an item has been previously made as a casting and development proves that it can be produced more cheaply of equal quality as a forging, the course to be followed is obvious. Other things being equal, cost of production is the determining factor. We have in mind an item illustrated here, which was designed originally as a steel casting and for quite some time was made as a steel casting. It was entirely satisfactory as a steel casting until consideration of economy prompted a change in the method of manufacture and it was made for a while thereafter as a forging. As a forging it was quite acceptable until it was decided to make a major change in design. This would have made necessary a new die, the cost of which was not justified, and for this reason the part was again made as a steel casting. Experiment and development then showed that this piece could be drawn under the hammer from a plate and cut to shape by flame cutting, this operation being performed in multiples of six at a time, bosses being applied by electric arc welding. At the present time, this is the method used (Fig. 5).

We illustrate an interesting comparison between a cast and welded structure of interchangeable design. This item was designed originally as a steel casting. In ordering these pieces singly it appeared that a single welded job was more economical to produce than the steel casting and it was so made. The prospect of an order for a number of these prompted a change back to the casting method, as the pattern charge diminished according to the increased number. Figure 6 illustrates the comparative cost of the two methods in the various quantities up to fifteen. It then transpired that the customer desired several pieces to a changed design. The changes having been made, the design was again produced as a weldment. Later, another order for fifty pieces resulted in changing the item back to a casting, with but a slight change to the original pattern.

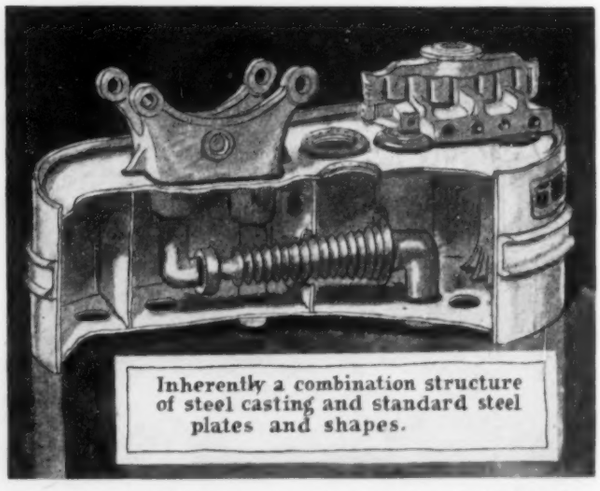



Fig. 3—Experimental Reactor Length 9 Feet 2 Inches, Height Over Tank 49 Inches, 47 Inches Wide. Two Steel Castings, One Assembly Made of Three Steel Castings Welded Together

## HOW TO USE CASTINGS

As to the question of how to use steel castings in welded fabrication, we know that they may be used as an integral detail of a specific part of a complete structure, such as an intricate head welded to the open end of seamless tubing. Or they may be used as an entire unit in a complete structure. The number of them used in a composite assembly and the extent of their application have no limitations within the bounds of reason. They may be applied completely machined, or they may be used unmachined and the machining done on the complete assembly as a whole. They should have the proper heat treatment before and after welding if and when such heat treatment is necessary. The benefits to be obtained by the use of steel castings as considered here must evolve from the fact that they offer the best solution to the problem in question.

## WHEN NOT TO USE CASTINGS

When the details of design can be so simplified that standard shapes and forms may be welded together to make a complete unit, there is obviously no point in using a steel casting. When the quantity is limited involving only one or two pieces, here again there is no special reason for a steel casting. A long and rangy structure with thin walls and simple physical characteristics should never be made as a single steel casting. Such a structure is inherently a welded fabrication. It can usually be readily assembled from standard plates, shapes and tubing. Designs of an experimental or preliminary nature, which are subject to changes during the progress of the work, can be readily taken care of by the welding process, and parts already welded together can be removed and others substituted (see Fig. 1).

Fig. 4—Combining Steel Castings

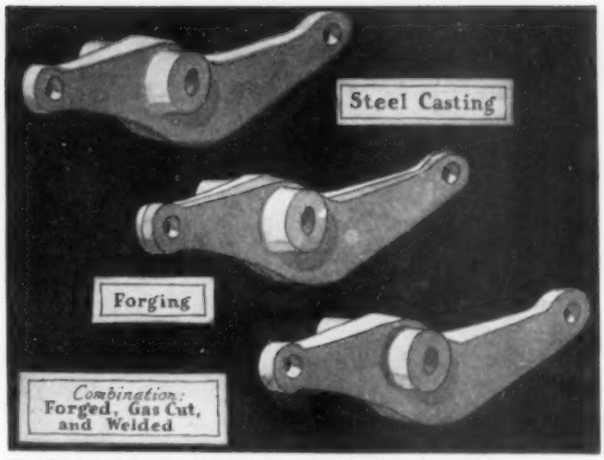



Fig. 5—A 0.20 Carbon Forging Combined with a 0.20 Carbon Casting

## STEEL CASTINGS WELDED TO STEEL CASTINGS

Steel castings are welded not only to steel plates and shapes, but also to each other, as component parts of a complete unit. A typical example of such a method is a large cast steel pump shell made recently. This item complete as shown in the illustration in Fig. 4 weighs approximately 14,000 lb. and in its extreme dimension is 11 feet 5 inches with an average wall thickness of $3^1/_2$ inches. It is provided with supporting feet which were originally cast integrally with the main portion. It was decided to cast the shell portion and the feet separately and then weld them together. This was done in order to overcome possible complications at the junction of the feet and the shell proper. The two feet and the shell portion were welded together without difficulty. All necessary precautions were taken to perform the work successfully. The feet were retained in place by simple jigs consisting of two pieces of 4-inch standard pipe tack welded between each foot and the flange at the end of the segment. These were removed after having served their purpose. The specifications called for a 0.45 carbon special alloy steel, consequently the electrodes and welding technique employed had to be those suited to this particular job. The shell and feet castings received the proper heat treatment before welding. By means of a circular gas jet the work was kept at a uniform temperature of 500° F. during the welding process. After welding, the completed unit was again heat treated. It may be of interest to note that the normal distortion caused by localized application of heat in the welding zone was overcome by using the proper sequence of skip welding (Fig. 4).

## WELDABILITY

Several excellent papers of recent date have been written on the subject of the weldability of steel. The

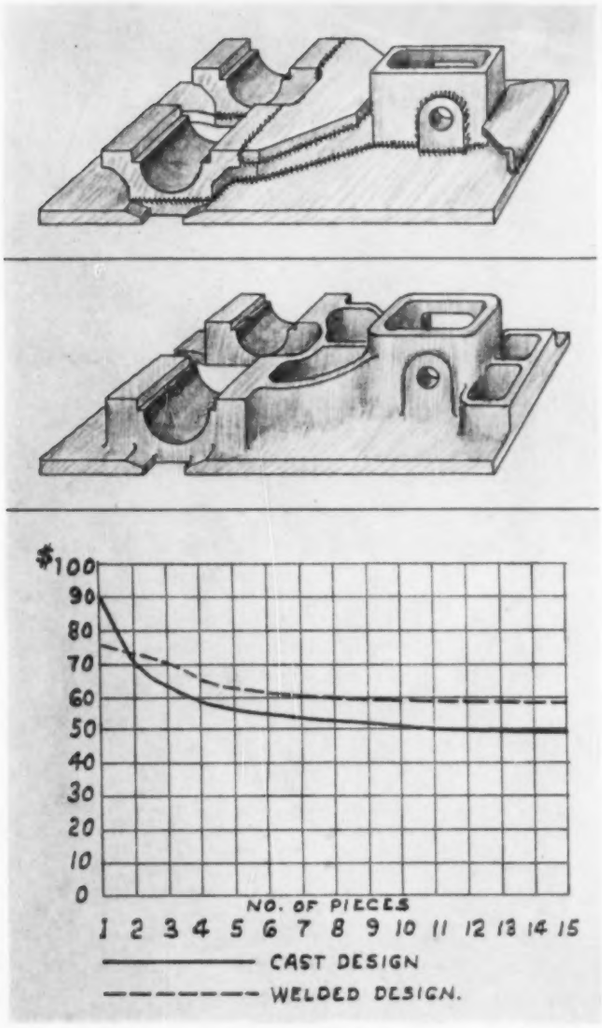



Fig. 6—Cost Comparison Between a Welded Construction (Top) and an All Cast Piece of the Same Type

subjects of these papers include both carbon and low alloy steels. It is not our intention to go into technical details concerning the weldability of the various cast steels, and we recognize the fact that much is yet to be learned on this subject. As a matter of fact, the Engineering Foundation hopes to inaugurate a program to study the effect of alloys upon weldability. Our experience indicates that steel in its cast form is as readily welded as any other steel. The material in the usual steel casting of 0.25 to 0.30 carbon can be welded with the regular coated electrode without special preparation. Castings of a special composition can be readily and reliably welded by using the proper electrodes and technique. This has been demonstrated so often that there is no question about it among those familiar with this class of work.

The welding of steel castings may be considered as involving three general phases such as the use of welding in the foundry as a finishing tool, welding in the field as a matter of repair or maintenance and the welding of cast to rolled steel in major or minor assemblies of machinery or equipment. The fact that steel is designated as weldable does not mean that welding technique and procedure, preheating when necessary, subsequent heat treatment and any other necessary preparation can be dispensed with. All these are details entering into the accomplishment of a successful welding job.

## DESIGN ENGINEERING

Industry has been on the alert for many years. It has always been engineering minded and is becoming more so every day. Two of the important branches of engineering that pertain to the use of steel castings in welded fabrication are design engineering and cost engineering. These bear a direct relation each to the other, since cost influences design and design influences cost.

To build a structure by welded fabrication is a relatively simple matter. To design it in such a way as to realize its inherent possibilities fully, is a problem requiring thought and a detailed knowledge of the principles involved. While the design engineer is vitally interested in theory such as stress concentration, he must also give considerable thought to methods and materials. Effective fabricated design will frequently include steel castings and forgings as well as rolled plate and standard shapes. In a broad sense welded fabrication involves the processes of casting, forging and welding. Fortunate is the design engineer who has at hand all three, for he is less liable to protagonism, and will approach a design with a more tolerant outlook. At the present time there are several organizations which have at their command these three processes, which can be used separately or in combination to produce the best results.

## COST ENGINEERING

Not many years ago cost engineering was a secondary feature in most engineering programs. This very often reflected itself in the attitude toward cost shown by various men throughout a plant. During a discussion on how a certain piece of equipment should be made, one individual upon being asked for his opinion said, he "guessed" that it should be a completely welded structure. The high point in his argument was that welding was the coming thing and that they would have to come to it sooner or later anyway.

So a welding it became, and so it continued to be for two years, the orders for this particular piece increasing to five, ten, and, finally, fifty pieces. Eventually the management called in an outside cost engineer to investigate the manufacturing costs throughout the plant and this particular welded construction did not escape his scrutiny. It was found that no constructive change or improvement had been made in all that time, and, above all, no record had been kept of the cost of the jigs, fixtures, templates, assembly or welding, the system being purely guesswork as it had been in the beginning. A scientific analysis resulted in a saving of 25% in the cost of the next order of fifty pieces, four similar steel castings having been added to the structure and the resulting product being entirely satisfactory to the purchaser.

Today the management knows both preliminary and final costs. The foremen of the various departments are becoming more cost minded day by day. Even the individual worker is well versed at least in such costs as concern him at the moment. Records are kept, essential data are compiled and the shop drawings are simplified by the use of symbols. These symbols may appear to be rather complicated. As a matter of fact, they are not. Experience has shown that they save time and help to avoid mistakes. Such symbols and a data sheet are illustrated in Fig. 7.

## CONCLUSIONS

In presenting an article on the use of steel castings in welded fabrication, it has been our purpose to show that castings are as important and vital as parts of such con-

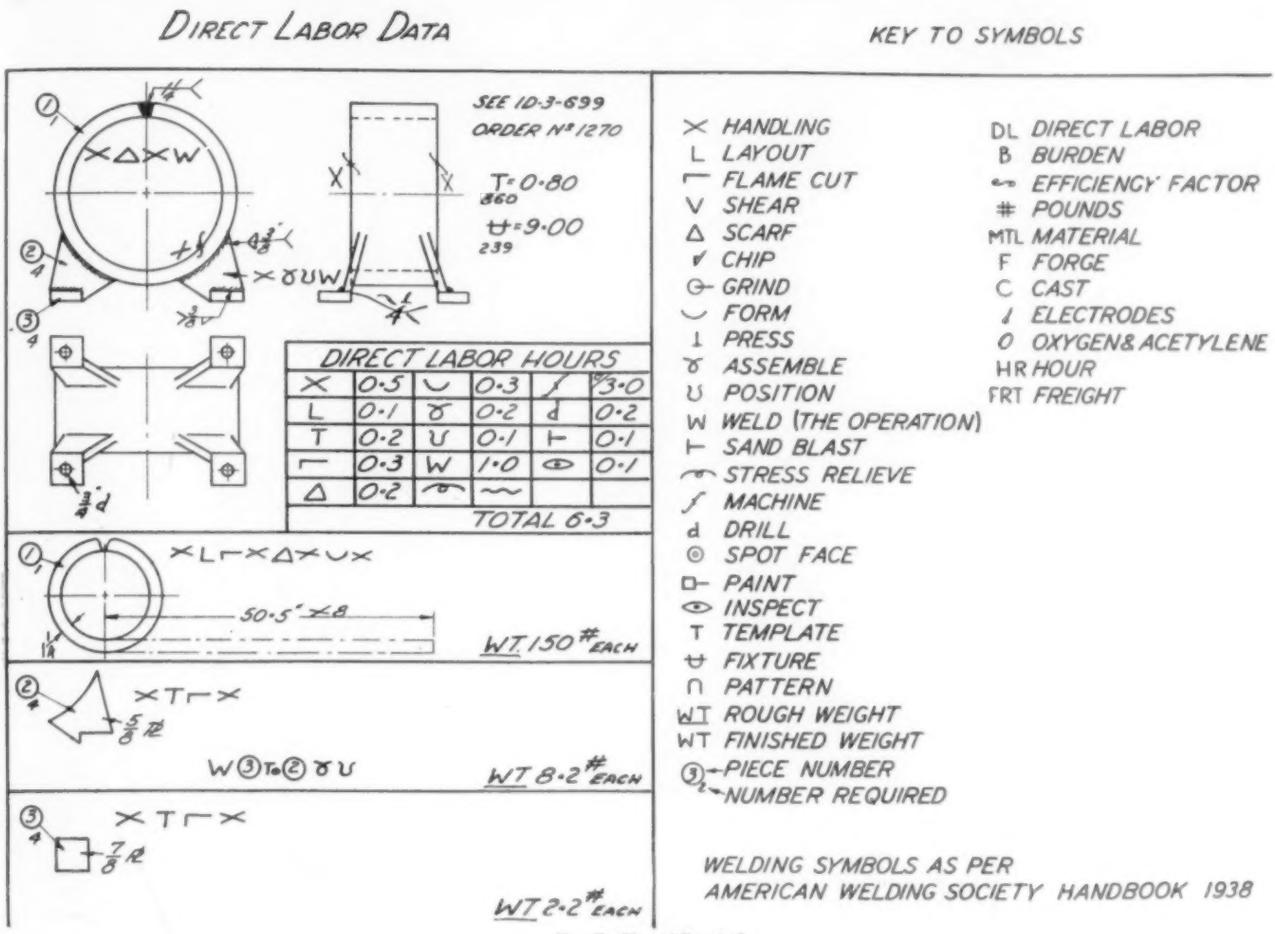



Fig. 7—Use of Symbols

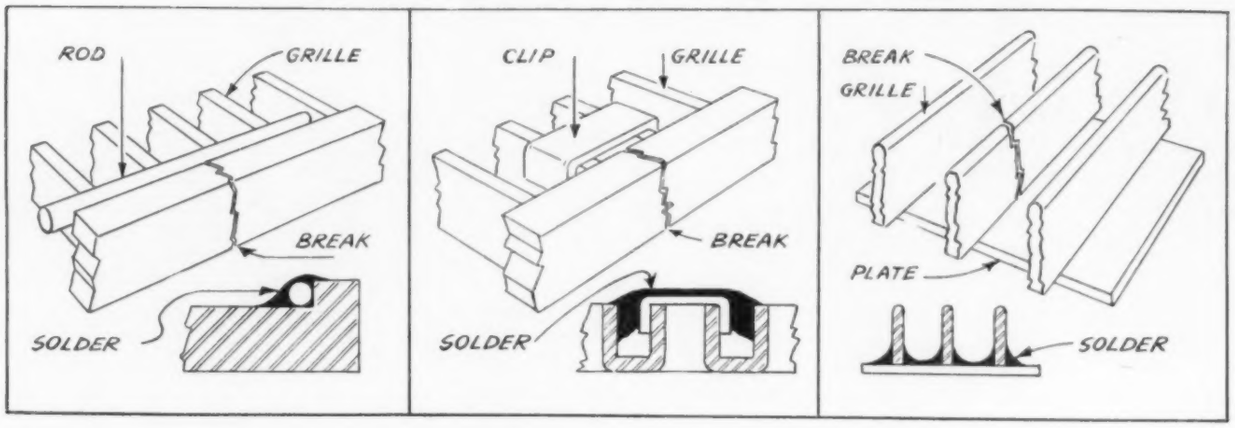
struction as are any other materials that may enter into it. We have produced a number of examples by way of illustration and we have tried to show that any given material possesses limitations which may be compensated for by the use of parts not having the same limitations but subject to others. By the use of the proper material or a suitable combination of materials, a balanced structure can be designed and built which in its completed form will best serve the purpose for which it is intended.

In offering the foregoing illustrations with their accompanying discussion on the use of steel castings and rolled steel plate in welded construction, we have attempted to throw a little light upon a subject which, we fear, has been somewhat beclouded by a controversial attitude on the part of many when there is no occasion for controversy. The interests of industry in general can best be served by an attitude of cooperation among and between all its members. Much confusion has prevailed in the past because the leaders of the many and diversified interests into which industry is divided have been too self-centered. A complete and comprehensive knowledge of all industry is impossible to any individual but a general understanding of the various processes which go to make up complete industrial structures should be the ambition of any responsible leader in the field of such effort.

We come in daily contact with men who are captains in their own specialized fields of endeavor and who are prone to advance what they consider to be their own interests against all others. This disposition is reflected in a similar attitude on the part of what we call his competitors, and the resulting conflict injures the industry as a whole. Not that we do not believe that healthy competition is beneficial—far from it—but a competition which refuses to admit that the other fellow has anything to offer and which refuses to avail itself of the benefits which might be derived from accepting his contributions to progress can be successful only despite itself.

In spite of all discouragements, in spite of depression and unemployment, progress will continue. It may be halted temporarily but it must go on. That is the history of mankind. The material comforts and advantages which we today enjoy are the gifts of industrial progress. The continuation of this progress and the extent to which it can develop in the future, depends upon the united and cooperating efforts of all of us, and the extent to which we can work together, all for one and one for all will determine how enduring that progress will be.

*These sketches show three types of reinforcing "splints" used in the repair of broken automobile grilles; (left) bronze rod, (center) copper clip, (right) copper sheet. Bronze welding rods make excellent reinforcing members, but should not be placed where they would interfere with fitting the grille into the car recesses. Clips are nothing more than small pieces of light-gauge copper sheet which can readily be cut to shape with a hand shear. For breaks on inside members, copper sheet, or lead-coated steel sheet should be used as indicated*




# HOW TO REPAIR WHITE-METAL Grilles

By H. H. MOSS†

## Chromium-Plated Automobile Die Castings Can Now Be Salvaged by Using New Technique

FOR the first time, a simple and dependable method is available for repairing cracked, broken and bent white-metal automobile grilles. This method is particularly applicable to chromium-plated die castings having insufficient white-metal body to permit repair by usual soldering or fusion-welding procedures. Garages, welding shops and body and fender shops, which formerly found it difficult or impossible to repair damaged grilles, can now handle this type of work with complete assurance of turning out a one-hundred per cent job. When it is considered that chromium-plated grilles are quite expensive, ranging from $15 to $50 or more, their successful repair means not only substantial savings to the car owner, but also opens up a new field for profits for the car repair shop.

* The Linde Air Products Company, Newark, N. J.

**Fig. 1—One-Half of This Chromium-Plated, White-Metal Grille Is Badly Bent Out of Shape, While the Other Half Is Broken Into Five Pieces**

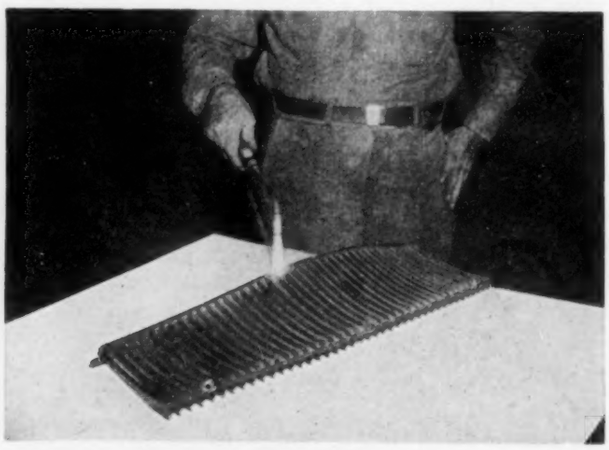


**Fig. 2—With the Flame Adjusted as Described on the Opposite Page, the Bent Section Is Heated Until It Is Just Hot Enough for Water to Boil Off**

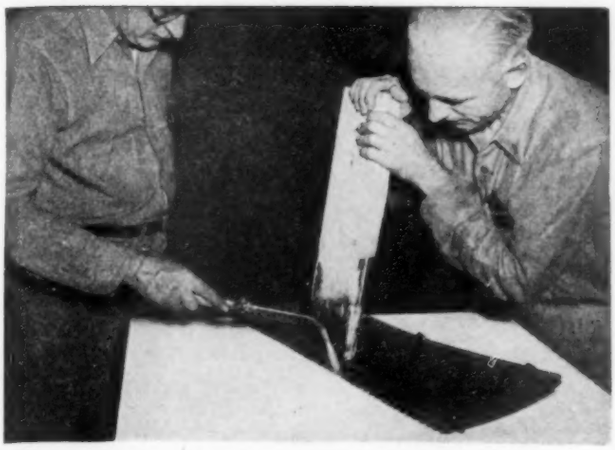


Fig. 3—While the Heat Is Continued, the Bent Section Is Straightened by Applying a Slow, Steady Pressure. Do Not Try to Hammer It Into Shape

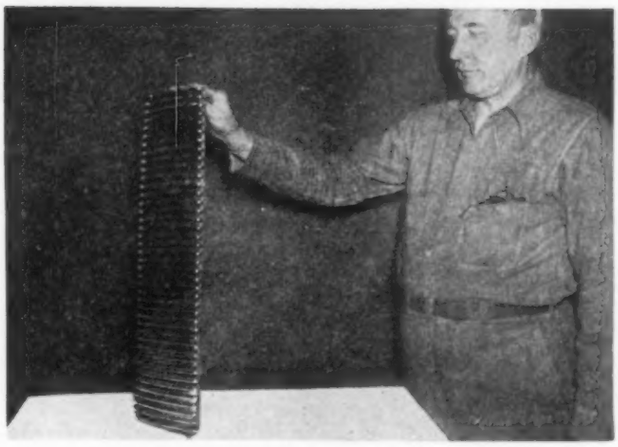


Fig. 4—Here Is the Straightened Grille. Too Little Heat Will Cause It to Crack During Straightening, While Too Much Heat Will Melt the White Metal

Briefly, the procedure for doing this work consists of applying half-and-half solder *directly to the chromium plating*, using a special *acid flux*, and reinforcing the solder with short pieces of bronze welding rod, bronze wire, copper sheet, copper screening or anything which will serve as a "splint" to give the solder strength across the break in the grille. The principle involved is very much like that underlying the making of reinforced concrete, where the steel reinforcing rods are used to provide the additional strength to the concrete which, poured around them, also serves to hold the rods in position.

## WHAT WHITE METAL IS

White metal, which is in widespread use today for automobile grilles, is a die-cast alloy of aluminum, zinc and tin. After the metal has been cast, certain surfaces of the grille are highly polished. Then the entire casting is chromium plated. The plating takes a high polish on all surfaces which were previously polished. On surfaces not previously polished, the chromium plating has a dull finish. As a final step in the manufacture of the grille, a black lacquer is usually applied to the dull surfaces so that the highly polished surfaces will stand out in comparison.

## HALF-AND-HALF SOLDER RECOMMENDED

White metal has a considerably lower melting point than the chromium with which it is plated. When heated above a certain point (about 800° F.), the white metal becomes spongy and soft, causing the chromium plating to collapse. Therefore, because the usual methods attempted have required at least this much heat, the grilles of this metal have heretofore been difficult to repair successfully. However, by keeping the temperature of the part being repaired well below 800° F., the white metal will hold its shape and, in turn, the condition of the plating.

Half-and-half solder (standard $^1/_8$-in. string solder), which is recommended for the operation, melts at about 400° F., well below the melting point of the white metal. The principal difficulty in the past, however, has been to find a flux which would permit the solder to tin the chromium plating.

## SPECIAL FLUX REQUIRED

The flux required for the soldering operation is commercial phosphoric acid. This acid can be obtained from any chemical supply house. Due to the corrosive-

Fig. 5—Lacquer Is Removed with a Lacquer Thinner from Sections to Be Soldered. Do Not Use a File or Emery Cloth as This Removes the Chromium Plating

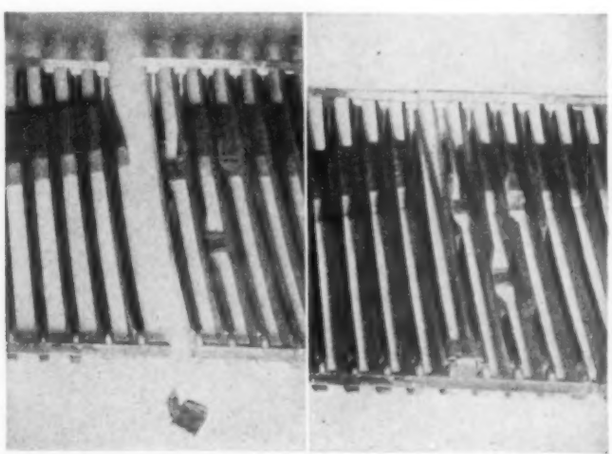


Fig. 6—After Two Broken Sections Are Aligned, a Reinforcing Clip, Made of Light-Gage Copper Sheet, Is Placed Next to the Break Between the Fractured Members

ness of the acid flux, care must be taken to keep it off the hands and clothing. Also, it should not be allowed to remain on the chromium plating after soldering; otherwise it will attack the plating adjacent to the soldered repair.

## HOW TO ADJUST THE FLAME

The proper flame adjustment is important in order to prevent overheating of the white metal. Following are the steps which should be taken in obtaining the correct flame.

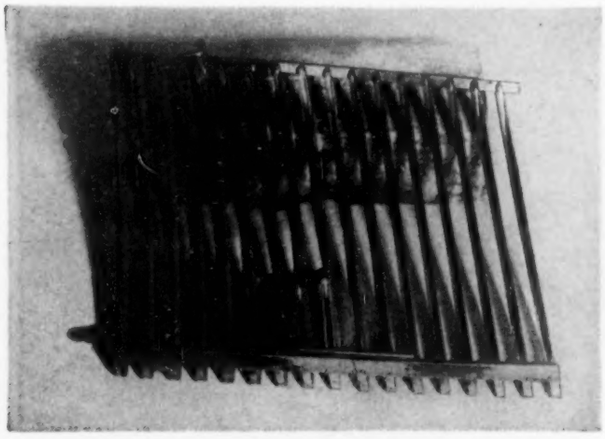


Fig. 7—Bronze-Welding Rod Is Used as the Reinforcing "Splint" at the Opposite End of the Break. All Clips and Rods Are Placed on the Back Side of the Grille

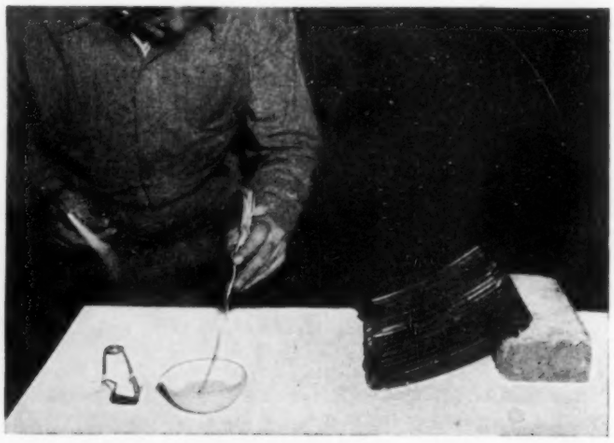


Fig. 8—Acid Flux, Is Spread on the Area to Be Soldered. Heat Is Then Applied, Holding the Blowpipe Tip About 6 In. from the Work

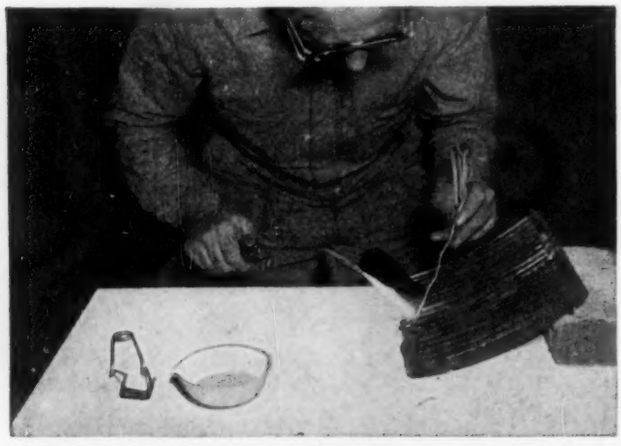


Fig. 9—When the Flux Starts to Boil, the Metal Is Hot Enough for Tinning. Then the Entire Area Is Built Up Until the Rod or Clip Is Firmly Anchored

Fig. 10—After Cooling, Parts Should Be Washed with Water to Remove Excess Flux. High Spots Can Be Removed Readily with a File

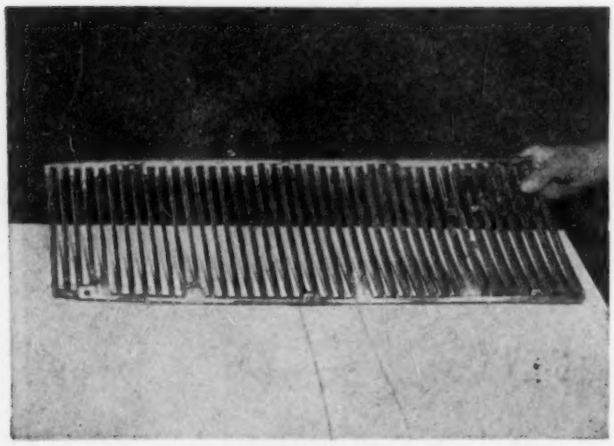


Fig. 11—This View Shows the Back Side of the Repaired Grille. Four Clips Are Embedded Along the Bottom and Four Short Lengths of Rod Along the Top

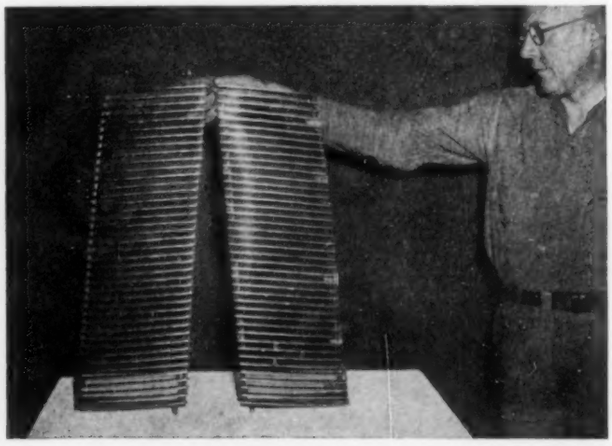


Fig. 12—Here Is the Completed Job. The Repaired Areas Will Not Be Noticeable When They Are Re-Lacquered and the Grille Is Replaced in the Car

Using a No. 1 tip, adjust the oxygen and acetylene pressures as recommended in the instructions for operating the blowpipe. This produces a harsh, neutral flame with an inner cone about $^1/_8$ in. in length. Next, cut this neutral flame in half so that the length of the inner cone is about $^1/_{16}$ in. This should be done by adjusting the valves on the blowpipe. Finally, reduce the oxygen supply still further so as to produce a slightly excess acetylene flame with a long outer envelope. This flame is 10 to 12 in. long, narrow and bluish, and is typical of that used for many soldering operations.

#### STEP-BY-STEP INSTRUCTIONS

The photographs on the following two pages illustrate the step-by-step procedures for repairing a broken and bent white-metal grille. It should be borne in mind that the correct flame adjustment, solder and special flux are essential in obtaining a good job.

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# WELDING METALLURGY

By O. H. HENRY and G. E. CLAUSSEN

A series of lectures prepared for presentation in a fundamental course of metallurgy and metallography at Polytechnic Institute of Brooklyn under the joint auspices of the Institute and the New York Section of the AMERICAN WELDING SOCIETY. To be published serially in The Welding Journal. Available in Pamphlet Form—47 pages Journal Size. Copiously Illustrated at $1.00 per copy. Special Prices quantity lots ten or more.

## Part III—Crystals

As a rule we know that solid metals are crystalline. To understand crystals we recall that everything is composed of atoms. An atom consists of a nucleus and a number of electrons. All electrons are alike, electrified particles of negative charge weighing $10^{-27}$ gm. ($10^{-27}$ gm. = 0.000000000000000000000000001 gram; that is, a thousandth of a quadrillionth of a quadrillionth of a gram; there are 454 grams in a pound).

The 92 different types of atoms differ in size of nucleus and in number of electrons. In the fluid condition, whether gas or liquid, two or more atoms frequently combine to form molecules. The atoms or molecules move freely among themselves. In a gas there is a lower limit to the closeness with which the atoms or molecules can be packed by low temperature or high pressure, but there is no upper limit. In a liquid, on the contrary, the atoms are practically the same distance center-to-center from each other as they are in solids. But the atoms of a fluid may move freely among themselves, and as a result, the fluid is mobile and yields readily to the slightest pressure.

Since the atoms or molecules of a fluid move freely in all directions they possess very little ordered arrangement. In a crystal, atomic arrangement takes the place of disorder. A well-formed crystal possesses geometrical form; it is bounded by a number of plane surfaces, which are inclined to one another at characteristic angles. These planes are parallel to planes upon which atoms are distributed throughout the crystal.

The arrangement of planes in a crystal is called the space-lattice, a two-dimensional simplification of which is shown in Fig. 3, which applies to a cubic crystal, shown at (*b*). The atoms are at the points of intersection of three planes; that is, at the intersection of two lines in (*a*). They may be elsewhere in different types of cubic crystals. In addition to cubic crystals, there are rhombic, hexagonal and other types.

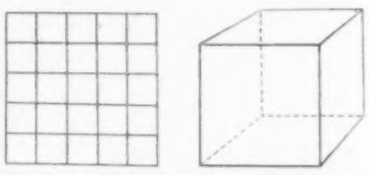

Fig. 3 (*a*) (Left)—Simple, Two-Dimensional Example of a Cubic Lattice (*b*) (Right)—Cubic Crystal

The space-lattice arrangement of crystals is important for two reasons: 1. It shows that the properties of a crystal will be the same along the same type of plane, but different along different types of planes. For instance, the resistance to corrosion will be different if one of the cube faces in (*b*) is exposed to the corroding medium than if the diagonal plane of the cube is exposed. 2. The electrical and magnetic forces which knit the atoms together tend to prevent movement. Hence, crystals are harder and less mobile than all other types of atomic aggregates.

The shortest distance between atoms in metal crystals is measured by means of X-rays and varies with the composition of the crystal and its temperature. The closest approach of atoms in most metal crystals is about 3 to 6 $\times$ $10^{-8}$ cm. (about 0.000,000,02 inch). The closest approach results from a balance of attractive and repulsive forces between atoms. Beneath the surface of a crystal the field of force surrounding an atom is entirely in equilibrium with the neighboring atoms.

#### Growth of Crystals

An atom at the surface of a crystal is not surrounded on all sides by neighbors. It, therefore, possesses available energy which is directed outwardly from the surface of the crystal. The crystal thus possesses surface energy, by means of which it can attract other atoms to itself, and if environment is suitable, it can grow. The surface energy, and therefore the capacity for growth, is different depending on the type of plane that is exposed. The cube faces usually possess the greatest capacity for growth in cubic crystals. The polyhedral form of free crystals shows that they grow with different

velocities in different directions; otherwise they would be spherical.

Crystals grow by addition of thin layers of atoms to their faces. The atoms for growth may come from metal vapor (gas), liquid metal, ionic solution (for example electroplating) or solid metal (recrystallization). Growth from liquid and solid metal is important in welding. Before discussing freezing and recrystallization, we will recall two facts about metal crystals.

1. The space lattice or crystal structure of a metal depends upon the element or elements present and on temperature (pressure can be neglected for metals and little is known about the effect of environment). Since the atoms in a crystal are held together by forces, it is easy to see that temperature, which affects the energy of the atoms, and the size of nucleus and number of electrons in the atom are the two vital factors determining whether the atoms can be in equilibrium in a cubic arrangement or in a hexagonal or other arrangement. If two or more elements are present simultaneously in a crystal they may each exist as independent crystals; for example, crystals of nearly pure iron existing side by side with crystals of nearly pure copper in an iron-copper alloy. Under these circumstances we say that the two metals are practically *insoluble* (practically because our analytical technique is not sufficiently sensitive to prove complete insolubility of any two substances). If, however, the mixture of two or more substances crystallizes to form but one type of crystal, the elements involved are either in some sort of *combination* if the resulting crystal is different in type from the lattice of any of the elements involved, or are *soluble* in each other, if the resulting crystal is of the same type as one of the elements. Solubility can be complete or can be partial to any degree. An example of combination is iron and carbon, which combine to form iron carbide, a compound found in many steels. An example of a pair of elements which are soluble in each other is copper and nickel. Practically complete insolubility is exemplified by solid iron and solid lead.

2. The crystal structure of a metal determines its mechanical properties to a surprising extent. Body centered cubic crystals, Fig. 4 (*a*), such as alpha iron and tungsten, are characterized by high yield strength and limited cold workability. Face centered cubic metals, Fig. 4 (*b*), such as copper, are characterized by lower yield strength but greater capacity for cold work, to mention but two of the properties affected by crystal structure. If we reflect on the difference in arrangement of planes in the different types of crystals and remember that deformation of metal crystals is allowed because slippage occurs between the atomic planes that are farthest apart, we can easily understand the effect of crystal structure on mechanical properties.

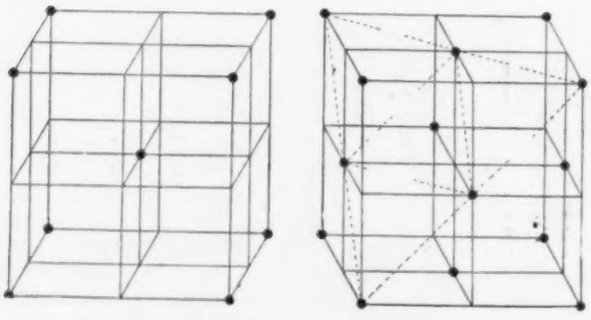

Fig. 4 (*a*)—(Left) Body-Centered Cubic Crystal
(*b*)—(Right) Face-Centered Cubic Crystal

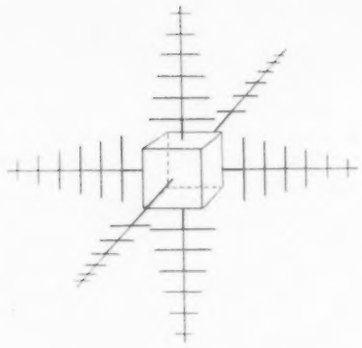

Fig. 5—Dendritic Growth of Crystals

### How a Crystal Grows from the Melt

We have seen that the atoms of a liquid metal move freely among themselves. When, as we cool the melt, it reaches the freezing point, some group of atoms fit themselves into the correct position to form a minute crystal, called a nucleus. Although we know that nuclei form at the onset of freezing, the manner in which the atoms of the nucleus come together is one of the unexplained occurrences in nature. A split second before the nucleus forms, all the atoms move freely among themselves. A split second afterward there is a bit of elastic solid in the melt.

Once the nucleus has formed, the crystal grows by additions of sheets of atoms on the growing plane. The type of planes upon which growth occurs depends a great deal on the rate of growth of the crystal. The rate at which metal crystals grow from the melt usually is proportional to the rate at which heat is withdrawn. For a cubic crystal, such as iron, the crystal grows out into the melt in three directions at right angles, Fig. 5, corresponding to the six faces of a cube. The resemblance of crystal growth to a pine tree with its branches has given rise to the term DENDRITE to a growing metal crystal. Unlike salt and other substances which often crystallize from water solutions as compact, well-shaped crystals, metal crystals grown in the melt have a pine-tree, dendritic appearance. If the entire melt solidifies to form a *single crystal*, it will have the shape of the interior of the crucible, and will occupy slightly less volume than the liquid. Although the atoms of a crystal are slightly closer together than in the melt (they are farther apart than the melt in bismuth), the crystal has practically no capacity for flow in the sense that a liquid has.

Examine a glass of cold soda water from which the carbon dioxide is being evolved as tiny bubbles as the liquid grows warmer. The bubbles form at the walls of the glass, from which they become detached by buoyant force and rise to the surface. The gas is evolved on the wall for two reasons. First, the glass, being in contact with the air, is warmer than the water. Second, there are minute peaks and valleys on the surface of the glass, which have high surface energy and therefore favor physical and chemical changes which require a little excess energy to set them off.

There is a similar situation in the freezing of molten metal. The heat is abstracted from the crucible through the walls. Convection ordinarily maintains the surface of the melt at the highest temperature. Consequently, crystal nuclei first form at the walls and bottom of the crucible, ingot mold or weld gap, Fig. 6.

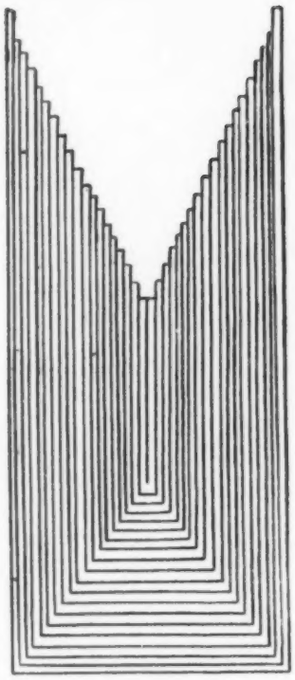

Fig. 6—Stages of Freezing of Metal in a Mold. See Also Fig. 41, in Which, at the Left, Crystals Have Formed at the Sides and Bottom; At the Right, These Have Grown Into Columnar Crystals

When the crystals have grown to cover the mold wall, the remaining liquid is, in effect, contained in a mold consisting of its own crystals. These crystals continue to grow into the melt until all the liquid is used up. The resulting ingot is said to exhibit *ingotism*, and the crystals which have grown in one direction only from the wall are called *columnar* crystals, because they are long and thin. Any shrinkage cavity is called a *pipe*.

Since nuclei have formed at a number of points along the wall, the solid consists of a number of crystals and is known as a polycrystalline solid. Generally the main planes in any one crystal will be at an angle to the planes of adjacent crystals; that is, the crystals of a polycrystalline solid have different *orientations*, Fig. 7, which is nearly always the case in rolled or welded steel.

The grains have irregular curved boundaries instead of straight boundaries with sharp corners, for the reason that the numerous branches of a dendrite do not grow at equal rates. The ends of the branches of a given crystal therefore reach the ends of branches of other crystals at varying distances from the axis of the crystal, Fig. 8.

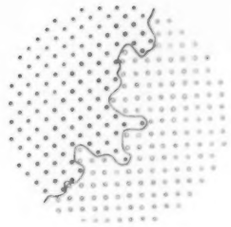

Fig. 8—Boundary Between Grains of Different Orientation

Let us now analyze crystallization from the standpoint of heat. We know that when a substance freezes it evolves heat. Conversely a crystal absorbs heat when it melts. As soon as a crystal nucleus forms, it gives off heat, which tends to offset the temperature drop in its vicinity. The heat evolution tends to stop further growth of the crystal and to favor the growth of new nuclei, which explains the rarity of large single crystals of metal. The heat evolution also arrests the drop in temperature of the melt, which is in accordance with our knowledge that the freezing of a pure material occurs entirely at a single temperature, the melting point. When all the liquid has solidified, the temperature once again falls, Fig. 9.

One phenomenon in crystallization that has practically no importance for welding is undercooling. If a metal cools without agitation, the temperature may drop many degrees below the freezing point before crystallization occurs. Depending on the temperature, the melt may then crystallize from an extremely large number of nuclei, or if the temperature is sufficiently low it may not crystallize at all. The unusually "cold" liquid generally has extremely high viscosity and is called an AMORPHOUS (non-crystalline) solid. Borate fluxes and silicate welding slags exhibit the tendency to undercool and become glasses. Liquid weld metal, on the other hand, never undercools to any extent because it is always in contact with metal crystals (base metal) of about the same composition. However, it is true that if liquid metals are cooled very rapidly, more nuclei form and there are more grains in the solid, hence the crystals are smaller than with slow cooling. Coarse grains in steel weld metal are undesirable, because they have only a fraction of the notch impact value of fine grains of the same composition.

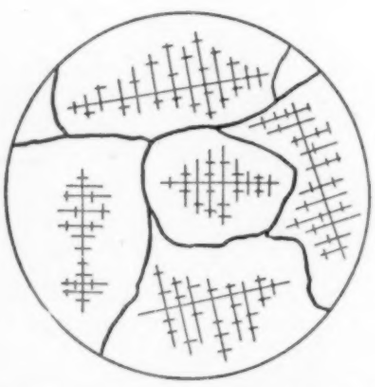

Fig. 7—The Individual Grains of a Metal Grow from Individual Nuclei and Dendrites

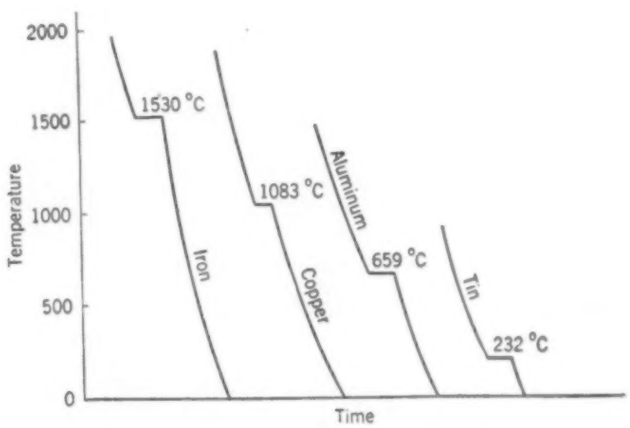


Fig. 9—During Cooling the Temperature of a Pure Metal Remains Constant at the Melting Point Until All the Metal Has Frozen

It is a general rule, too, that the higher the temperature from which a liquid metal is cooling, the larger will be the size of the crystals in the ingot or weld. Overheating lowers the rate of cooling, which would tend to decrease the number of crystals, but overheating also may dissolve foreign particles, such as graphite in cast iron, which, if not dissolved, act as nuclei in the melt. Little is known about them, but if they exist in the melt, as they often do, nuclei form in advance of the growing columnar crystals. These new crystals grow in all directions, get in the way of, and stop the columnar crystals, and are called equiaxed crystals, because they grow the same amount along each axis. The solution of nuclei in melt depends on duration of melting as well as on temperature. That is, although more salt dissolves in hot water than in cold, more salt will dissolve in 10 minutes than in 10 seconds. The short time during which weld metal is molten may lend importance to the time factor.

### Polishing and Etching

In order to examine the structure of a weld under the microscope, a sample must be cut from the weld and heat-affected zone. The cut surface (not over an inch square) is ground or filed flat as the first step in securing a plane polished surface free from scratches. The ground surface is rubbed on emery or carborundum papers starting with grade 1 and going through 0, 00, and perhaps 000 and 0000. In passing from a coarser to a finer paper the specimen should be turned 90 degrees so that elimination of the coarser scratches by the finer can be observed. After the last paper the specimen is cleaned and held on a wet disk charged with jeweler's rouge. The disk may be 6 inches in diameter and may revolve at 750 r. p. m. (complete details for metallographic polishing and etching are given by *A. S. T. M. E3-36* and by *Metals Handbook*, 1939 Edition, pp. 170–175, 722–735, etc.).

The as-polished surface, when examined at a magnification of 100 or 500 diameters (100× or 500×), is uniformly reflecting and featureless unless there are cracks, blow-holes, or non-metallic slag inclusions in the specimen. Polishing pits and scratches should not be confused with the structure of the specimen. Occasionally a harder metallic constituent will polish in relief and thus will be visible in the unetched specimen.

Etching is performed by dipping the polished surface in a suitable reagent, which for steel is 5% nitric acid in alcohol (Nital) for example. The etching reagent may do no more than reveal the grain size by attacking different grains to different extents. In this way one grain will reflect less light to the observer's eye than a neighboring grain and will appear darker. The etchant also may bring out the grain boundaries, and may attack one constituent at a faster rate than another. For instance, Nital dissolves ferrite in steel but scarcely attacks iron carbide. Etching thus reveals grain size, and state of heat treatment and cold work, and distinguishes between different types of crystals that may be present.

### Questions

1. What is meant by "crystal?", by "lattice?"
2. In what way does a body centered cubic crystal differ from a face centered cubic crystal?
3. Trace the path of an atom in a liquid (convection currents). What happens when the atom "freezes?"
4. Why are dendrites formed?
5. What is a grain boundary?

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# All Welded Hull for 25-Ton Floating Diesel Electric Crane

By J. F. SMITH*

ONE of the most interesting welded boats built in the current year was the 25-ton floating crane for the Bureau of Yards and Docks of the Navy Department. It was completed at our Wilmington Yard and delivered to the Navy Department, who put it in service at their Norfolk Yard at Portsmouth, Virginia. The hull of this boat is 100 feet long, 45 feet wide and 8 feet 6 inches deep. Larger hulls have been constructed this year, but the interesting feature of this boat is the fact that it is the first all-welded hull purchased by the Bureau of Yards and Docks.

The inspection of workmanship by the Navy Department Inspectors was in accordance with their usual rigid requirements and all welders and tack-welders working on this contract were required to take special welding tests. Twenty-eight welders were qualified for both the shop and yard welding. The welding wire used was also required to pass through a series of rigid tests at the manufacturer's plant before being released for shipment to our Neville Island shop and Wilmington Yard.

The hull was designed to permit the shop fabrication of large box sections which greatly reduced the amount of vertical overhead yard welding, thus permitting the most economical construction and securing the maximum benefits of positioned shop welding.

The hull was built in our Neville Island plant in five divisions for shipment to Wilmington; namely, rake end sections, side-box sections, deck and bottom plating, whirler base, bulkheads and all interior framing. The two rake ends, shown in the photograph Fig. 1, were built complete in the shop. The rake frames were accurately assembled and welded in jigs and then mounted in their respective places on the collision bulkhead after which all plating was fitted in place and the units were positioned for downhand welding. Each rake end weighed 25 tons and required approximately a half mile of welding.

Figure 2 shows one of the side-box sections in place in a positioning jig for downhand welding. The shop fabrication of these large units is facilitated by the use of such jigs whereby a maximum amount of downhand welding can be obtained. Downhand welding produces stronger welds than flat horizontal welding because the fillet legs are always of equal length and the penetration at the throat of the weld is 10 to 15% deeper for downhand welding than for flat horizontal welding. Three box sections, 26 feet 0 inch long, 6 feet 6 inches

* Welding Engineer, Dravo Corp., Neville Island Station, Pittsburgh, Pa.

Fig. 1—Forward and Aft Rake End Sections Setting on the Collision Bulkheads Prior to Welding

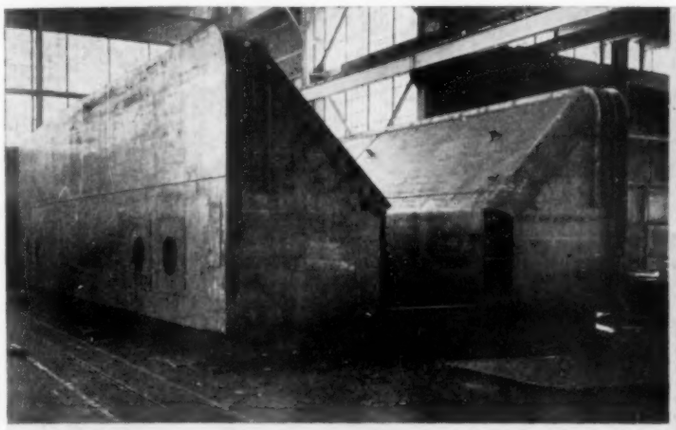
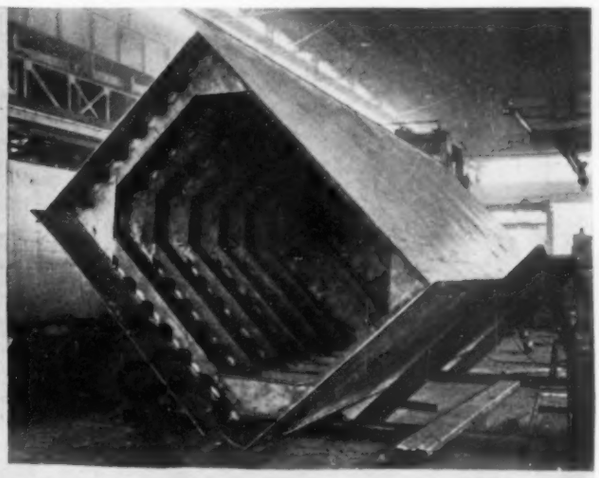


Fig. 2—Wing Tank Section in Position for Down hand Welding. Note Serrated Angle Construction of the Wing Frames



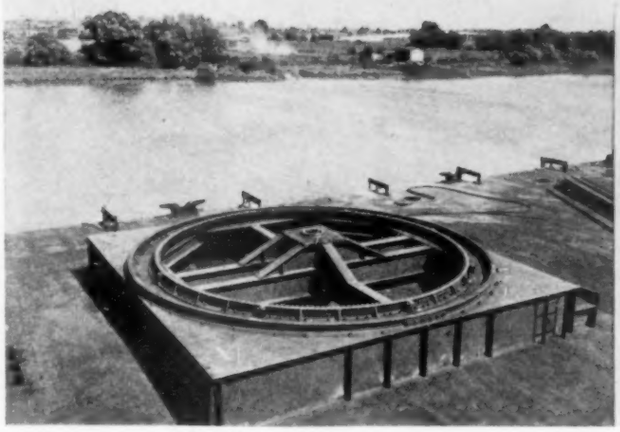


Fig. 3—Welded Whirler Base on Deck of C 20 Diesel-Electric 25-Ton Navy Floating Crane

Fig. 4—Showing the Hull During Early Stage of Construction

wide and 8 feet 6 inches high, similar to those shown in Fig. 2, were used on each side of the hull. They were built in a similar manner to the rake ends, that is the wing frames were made first in jigs and then used as framing members to facilitate the shaping of the box sections.

Fig. 5—Completed Crane at Dravo's Wilmington Yards, Lifting the Test Load

Figure 3 shows the whirler base welded in place on the deck of the hull at Wilmington, Del. This base was completely assembled, including the crane rail, rack casting and stediment bearing, in our Neville Island shop and was designed for shipment in two halves. All welding was completed in the shop before the unit was disassembled for shipment, and upon arrival at our Wilmington Boat Yard the two halves were rejoined and the whole unit, weighing about 13 tons, was leveled up before it was welded to the deck. This procedure saved many hours of costly vertical and overhead welding.

Figure 4 taken at Wilmington, Del., shows the hull under construction. The bottom plates, longitudinal trusses, transverse bulkheads and several of the side box sections are in place.

Figure 5 shows the finished crane in service at Norfolk Navy Yard. The whirler mounted on this hull is of the full revolving Diesel electric type. A gooseneck boom is used to provide vertical clearance. The capacity is 25 tons on the main hook at a maximum radius of 55 feet with an auxiliary hook having 5 tons capacity at a maximum radius of 65 feet. All operations of the crane, consisting of boom hoisting, raising of main and auxiliary hooks, as well as rotating, are secured by independent motor operation.

# LATEST DEVELOPMENT IN Resistance Welding*

By R. T. GILLETTE†

THE whole art of welding is developing so rapidly that it is difficult to keep up to date in what is happening in the welding field. While resistance welding is over fifty years old, more progress has been made in the last five or six years than in the rest of its life in placing welding on an accurate scientific basis where it belongs but a tremendous amount of work still remains to be done to secure and tabulate the accurate welding data so much needed at present. To avoid confusion, a few of the developments in equipment and procedure of the several types of resistance welding will be taken up separately.

## CONTROLS

Perhaps mention should be made first of controls as they so vitally affect all welding methods. The control of early welding equipment was all manual. It was soon recognized that this type of control was inadequate, particularly for the shorter time required to make welds as production speeds increased. The time current was applied manually and was very erratic and inconsistent. Perhaps one of the earliest controls was the follow-through switch used, both on manual and mechanically operated machines. This was inaccurate and gave considerable trouble due to non-synchronous switching and variable timing, and was superseded by the cam limit switch contactor type of control. This was an improvement over earlier types of control and is still used extensively.

At about the same time various types of interrupters were used for seam welding including mechanically driven flapper switches, water pot interrupters and contactors driven by synchronous motors. There was a gradual improvement in this type of control but there was still considerable difficulty in getting consistent first quality welds, particularly on non-ferrous metals and alloys, aluminum, stainless steel and combinations of dissimilar metals.

At this time the electronic or vacuum tube controls appeared with their attendant accuracy in timing which is as accurate as the frequency of the circuit in which they are used. They also close the circuit at the proper point on the voltage wave to eliminate transient conditions, are arranged to give infinite steps of heat regulation by the phase shift control method, act as interrupter for seam welding and intermittent seam welding, and are used for interrupted spot welding which will be discussed in more detail. The electronic control is the most consistent control by far that is available for resistance welding. It is sturdy, noiseless in operation and simple to use. This control has been one of the most important factors in the development of a great many welding jobs which were formerly considered difficult or impossible.

While the original cost of electronic control may be higher than the cost of some other types of control, its lower electrode maintenance cost, noiseless operation, accuracy, flexibility, synchronous switching and the extremely low rejection of parts due to faulty welding more than justifies the difference in original cost.

Electronic controls must be synchronous in operation incorporating tubes to control and time the welder primary current to be assured of all the advantages of this type of control. Non-synchronous electronic timers which control a contactor do not show any improvement in quality of weld or lower electrode maintenance over the cam operated limit switch contactor control.

Ignitron tubes which are essentially single pole electronic contactors may be used to control the primary current of a resistance welder but there is no synchronous timing included. No external power is required as the tubes pass current when two terminals are shorted through a three-ampere control switch which may be a limit or other type of switch, cam, air or otherwise operated from the welding machine. Current flow ceases when the control switch is opened.

The advantages over other types of contactors are:

1. No moving parts.
2. Will operate 1800 times per minute as easily as it will once per minute.
3. Operates months without attention; no moving contacts to clean or replace.
4. Current flow always ceases at the zero point on the current wave.

When used with a non-synchronous timer the welds will probably be no better than those made with a magnetic contactor.

Synchronous timing is required for improved welds, improved electrode life and accuracy of all control factors.

## SPOT WELDING

The development of spot welding and the equipment for making spot welds has developed very rapidly in recent years. The early spot welders were very crude, manually operated, manually timed devices that had little use except for welding rather thin low-carbon steel, and could not be used satisfactorily for welding dissimilar metal combinations, aluminum and its alloys or other non-ferrous metals.

Recent developments in spot welding equipment give us motor driven, air or hydraulically operated spot welders which are really machine tools. They are built like and operate as consistently as any machine tool and should be cared for and considered as a machine tool.

Another factor that has quite seriously affected spot welding is the inertia of the moving element or head, electrode and lead assembly. In making a spot weld, pressure is applied through the moving element, then current is switched on and as the metal softens to the welding

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Fig. 1—Macrograph of Spot Weld Through Various Thicknesses of Steel Ranging from ⅛ In. to 1 In.

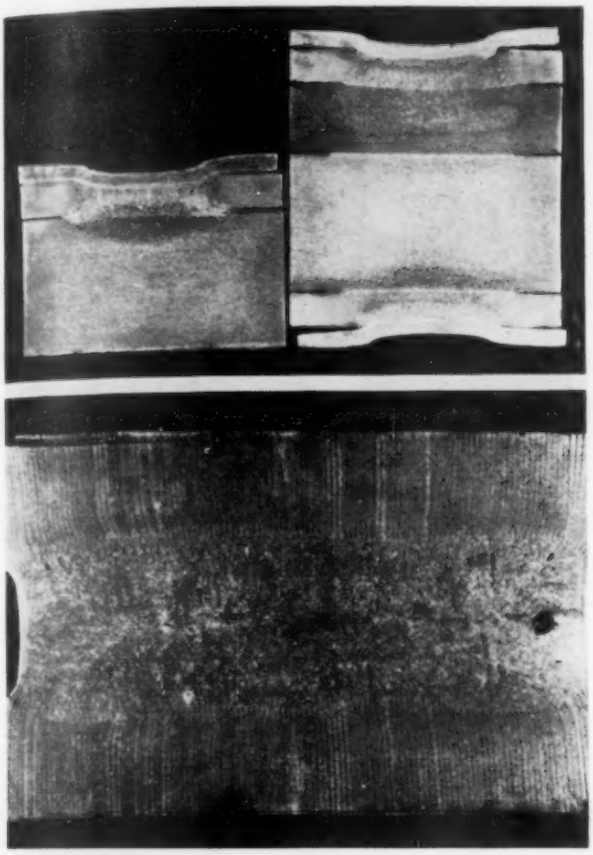

Fig. 2—Spot Weld Through 117 Sheets of Steel

temperature, the pressure on the electrodes must press the metal together to complete the weld.

When welding in very short time, particularly when welding a material of short plastic range, the time available to accelerate the moving element of a welder is very short. This factor is recognized and efforts are being made to keep the moving parts as light as possible and retain a sufficient amount of copper to carry current to the weld. The time left for pushing metal together in short time welding (1/2 cycle or less), after the metal has heated to the welding point, may be in the range of 1/600 to 1/750 of a second. If the pressure follow-up is too slow, burned work and high electrode consumption will result.

Another type of spot welding equipment is known as multimatic, speedmatic, hydromatic or ultra speed welders. These are made for a specific job and weld a complete assembly with one handling. They may be equipped with as many as 150 spot welding points or stations. An assembly to be welded is clamped to the fixtures of a machine of this type and one or more of several types of welding may be used. All electrodes may be brought in contact under air spring or hydraulic pressure and the secondary current commutated from one pair of series or multiple electrodes to the other. This commutating is done with the current shut off and is only switched on while the commutating device is on one contact segment. The actual timing and switching is usually done with an electronic control. These machines may also have several transformers in operation at one time.

This type of equipment welds a complete assembly while it is rigidly clamped to a fixture. This reduces any distortion or misalignment to a minimum. This type of welding equipment may be constructed in an unlimited number of forms and combinations.

## INTERRUPTED SPOT WELDING

When spot welding heavy material ranging from 3/16 inch to 1 inch, a great deal of trouble was experienced in electrode maintenance when a continuous flow of current was used. To correct this condition the interrupted method of spot welding was developed. This consists of bringing the electrodes in contact under pressure in the regular manner, then applying the current in a series of impulses rather than continuously. A typical welding procedure might consist of 10 cycles on and 5 cycles off, repeated 10 times for a certain thickness of material on a spot welder for a certain job. This interruption of current allows a welding temperature to be built up in the weld without excessive heat in electrodes or surface of work piece. To take advantage of the interrupted method of welding, adequate water cooling of electrodes must be used. The electrode life is greatly lengthened by using this method. No definite figures are available but 100 to 1 ratio seems very conservative.

The interrupted method also gives much better heat distribution on heavy material, allows time for good forging action on the weld and if burning or spitting starts the current interruption stops it and the next current impulse does not start it again.

An annealing cycle can also be arranged by this method which is sometimes of advantage on some alloy steels.

As an example, we might make a weld with 10 impulses of power, 6 cycles on and 2 cycles off, then after a dwell of 20 cycles off one more impulse 6 cycles as an anneal or heat treating application of current. Synchronous electronic control is of particular value in welding procedures of this type as interrupted spot welding such as just mentioned can be made fully automatic, and at the same time, transients in welding current will be avoided which might build up current of two or three times normal value.

The results of a few spot-welded tests made by the interrupted method might be of interest:

Fig. 3—¾ x 2 In., ¼ x 2½ In., and 1 x 3 In. Spot-Welded Steel Broken in Tension Test at 45,200, 44,400 and 97,500 Lb. (Respectively) Total Load

A test piece of multiple pieces of different thicknesses was made using the following thicknesses as listed; 1/8, 1/4, 1/2, 1, 1/4 and 1/8 inch welding the six thicknesses at one time using 4000-lb. pressure, 10 impulses of power, 11 cycles on, 8 cycles off, with 36,000 amp. and a 7/8 inch diam. copper alloy electrode tip. Figure 1 is a macrograph of this weld.

Next, 117 pieces of 0.044 inch low-carbon steel, 5400-lb. pressure using a 7/8 inch diam. tip of copper alloy, 7 impulses of power, 11 cycles on, 5 cycles off, 64,000 amp. Figure 2 shows this weld.

Lap weld 2 pieces 1/4 x 2 1/2 inches, 2600-lb. pressure, 5/8 inch diam. copper alloy, 35,000 amp., 4 impulses, 11 cycles on, 8 cycles off. Two welds in tandem broke in plate well removed from welds at 45,200 total load. Shown in Fig. 3.

Lap weld two pieces 3/8 x 2 inches, 4000-lb. pressure, 3/4 inch diam. copper alloy, 13 impulses of power, 7 cycles on, 7 cycles off, 39,300 amp. Two welds in tandem broke in plate well removed from weld area at 45,300 lb. total load. Fig. 3.

Weld two pieces 1 x 3 inches using long butt strap 1 x 3 inches lapped across two ends of other 1 x 3 inch pieces; one weld each piece; 11,000-lb. pressure, 1 inch diam. copper alloy electrode tip; 34 impulses of power, 21 cycles on, 51 cycles off, 73,000 amp. Broke in plate adjacent to one weld at 97,500 lb. total load. Fig. 3.

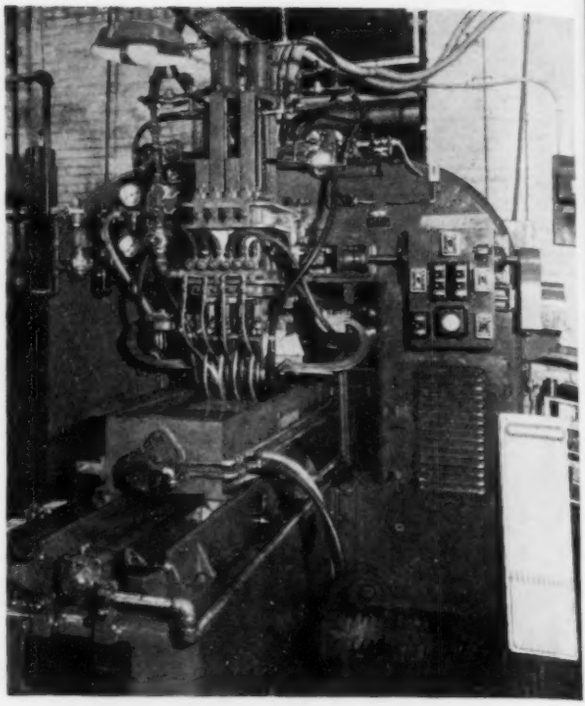

Fig. 4—4-Roll Series Seam Welder with Full-Automatic Control, for Intermittent Seam Welding of Refrigerating-Machine Evaporators. Front View

## SEAM WELDING

There has been a very rapid development in seam welding technique and equipment in the last few months. While there is still a very definite need for the old standard seam welder with a wheel top and bottom, they are being replaced on jobs where large production and design of parts permits by multiple wheel welders using the series system of welding; that is, placing two wheels above the work and with a properly designed fixture or conductor bar underneath the work, making two welds at one time.

This type of seam welder is adaptable to a great many types of work, particularly jobs of large size, like various types of cabinets, refrigerator parts and structures as large as rail cars. See article by A. M. Unger, AMERICAN WELDING SOCIETY JOURNAL, June 1938. A seam welder of this type having four wheels and two transformers and fully automatic is shown and fully described on page 205, A. W. S. Handbook 1938.

Seam welders of this type are also used to make long rows of spot welds as these machines are equipped with electronic interrupters. The only change necessary to make when changing from seam to spot welding is to set the interrupter for longer off time.

One of these welders, shown in Fig. 4, makes spot welds between two pieces of an 0.025-inch stainless steel refrigerator evaporator with the following procedure: Pressure 1000 lb., 3 cycles on, 3 cycles off, 11,000 amp., wheel speeds 150 inches per minute. With this procedure we get 4 spot welds per inch of travel of the work part or ten spots per wheel per second, a total of 2400 spot welds per minute per machine.

Another interesting seam welding equipment development is on a flat plate condenser made from two pieces of 0.037-inch low-carbon steel, Fig. 5. This part has 20 parallel seams, a total of approximately 900 inches of weld. These parts were originally welded on standard manually fed seam welders, Fig. 6, with a production of about 3 1/2 pieces per hour. After several steps of development a seam welder was built, Fig. 7, having ten welding wheels and five transformers, operating two wheels in series from each transformer with a splined shunting platen underneath. This machine is automatic in operation and has a production of one piece per minute. The following is the welding cycle, 1050-lb. pressure, 120 inches per minute, 2 cycles on, 1 cycle off, current 17,100 amp. Total kva. demand 1006, width of wheel faces from 3/16 inch to 5/16 inch.

This machine is fully automatic with hydraulic drive and indexing, and is controlled with five fully synchronous electronic interrupters. The welds are all made while the condenser is immersed in water. This reduces distortion to a minimum and reduces wheel maintenance. The quality of the product is exceptionally good.

An interesting job of seam welding was requested where a piece of 0.020-inch low-carbon steel was to be welded to 1/2-inch low-carbon steel. Test pieces were made to establish welding technique. Tests were also made at the same time to weld 0.020 inch to 1 inch, 0.020 inch to both sides of 2 inches and 0.020 inch to both sides of 4 inches. Samples are shown in Fig. 8. The following welding procedure was used:

Welding 0.020 inch to 1/2 inch, pressure, 1040 lb.
Wheel speed 16 inches per min., 13 cycles on, 19 cycles off.
Current amp. 12,960.
Welding 0.020 inch to 1 inch, pressure, 1040 lb.
Wheel speed 16 inches per min., 43 cycles on, 10 cycles off.
Current amp. 13,700.
Welding 0.020 inch on each side of 2 inches and 4 inches.
Pressure 810 lb., wheel speed 16 inches per min.
43 cycles on, 10 cycles off, current 14,280 amp.

A synchronous electronic interrupter was used to make all welds and a continuous flow of water was used over welding wheels and work. The width of samples was as follows: 1/2 inch was 3 inches wide; 1 inch was 3 1/4 inches wide; 2 inches was 4 inches wide; 4 inches was 2 inches wide.

The thin material was all welded to the thick in the flat condition and samples were tested to destruction by attaching a pipe nipple over a hole in the thin piece

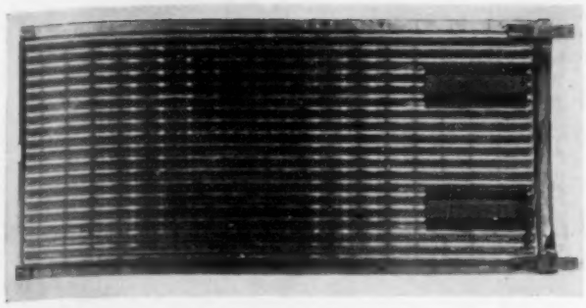

Fig. 5—Condenser for G. E. Refrigerating Machine, Type CF, Fabricated by Resistance Welding

and applying water pressure. The failure was inside of the weld line in all cases and was the typical failure in this type of test where the material shears due to the abrupt bend at the inside of the weld line.

The pressure required to cause these failures follows: 0.020 inch to 1/2 inch—700 lb./sq. in.; 0.020 inch to 1 inch.—800 lb./sq. in.; 0.020 inch to 2 inches—800 lb./sq. in.; 0.020 inch to 4 inches—1400 lb./sq. in. Before testing to destruction, all samples were tested with 80 lb. per sq. in. air pressure with no leaks in any case.

It is of interest to note that the stitch effect in these welds is very coarse, there being only approximately four welds per inch. If very close stitches are used in the order of twelve to fifteen per inch, the current seems to shunt back through the welds just made and practically no weld results. Also, if shorter interrupter time and higher wheel speeds are used there seems to be insufficient time to bring the heavier piece to a temperature where the thin piece will weld to it.

It has been thought that about two pieces of 1/8-inch material of like thicknesses were about the limit for satisfactory seam welding but our success with interrupted spot welding led us to have a seam welder built with an intermittent drive so the wheels would travel a fraction of an inch and stop while several impulses of power were applied, then advance a fraction of an inch and repeat several impulses of power.

By the use of this method satisfactory welds have been made on two pieces of 3/16 inch, 1/4 inch and 3/8 inch. Two pieces of 1/2 inch were also tried but the equipment available was not of sufficient capacity to successfully weld two pieces of 1/2 inch but it seems logical to believe that with the proper equipment, material heavier than two pieces of 3/8 inch could be satisfactorily welded. Accurate records of the exact welding technique used for these welds are not available. However, test records have been kept on samples of 3/16 inch, 1/4 inch and 3/8 inch. These samples were welded flat, tested at 80 lb. air pressure and found to have no leaks, then tested with water pressure to destruction with the following results:
3/16-inch sample 6 x 11 inches failed at 1400 lb./sq. in.
1/4 -inch sample 12 x 12 inches failed at 2200 lb./sq. in.
3/8 -inch sample 12 x 12 inches failed at 4500 lb./sq. in.
All failures were in material inside of weld line. Figure 9 shows these samples.

The General Electric Co. has done very little work in the development of butt and flash butt welding. The butt welding of copper to aluminum, however, has created a great deal of interest. See article in AMERICAN WELDING SOCIETY JOURNAL, October 1936, page 45. Other dissimilar metal butt welding jobs like copper to Nichrome and stainless steel, molybdenum and tungsten to nickel, and nickel to copper have been of interest.

Some of the flash welders recently built for continuous lengths of steel in the continuous strip steel mills are of particular interest.

## ELECTRODES FOR RESISTANCE WELDING

The recent advance in alloys available for spot-welding tips, seam-welding wheels and butt and flash butt welding jaws or dies has been of a great deal of value to the users of resistance welding, and range from pure tungsten

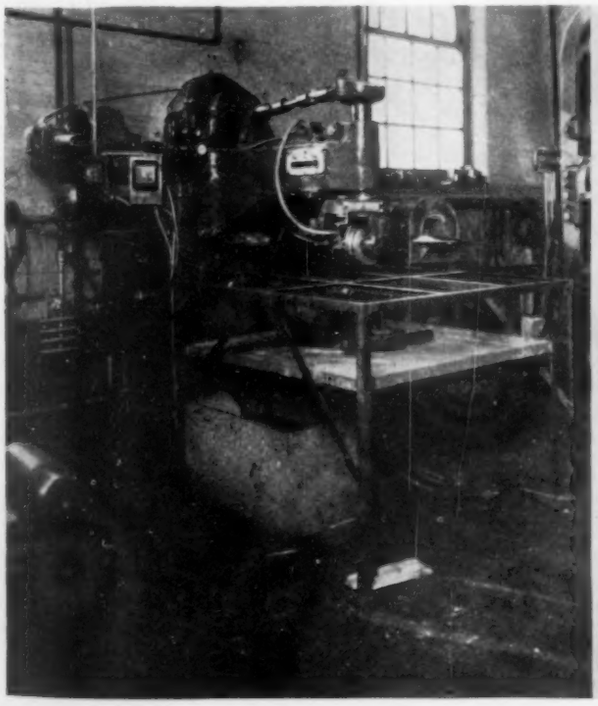

Fig. 6—Line Welder for Developmental Work, Building 44, Schenectady Works

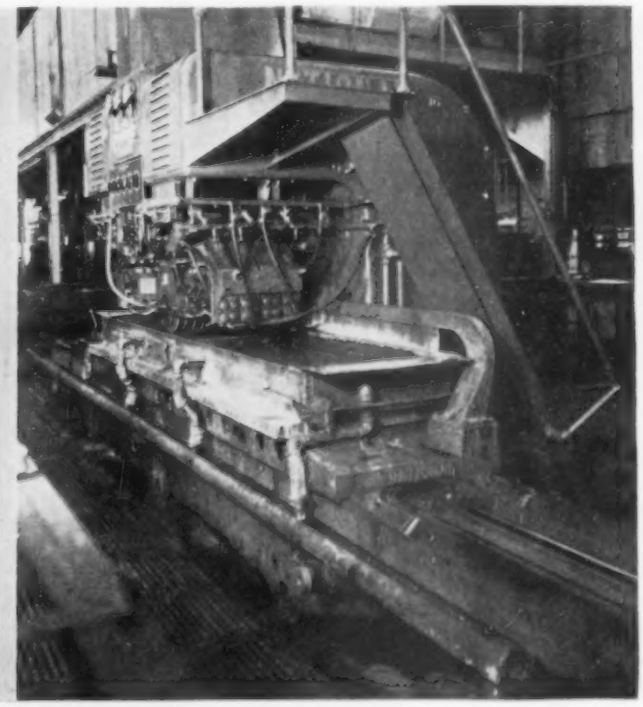

Fig. 7—Seam Welder Having Ten Welding Wheels and Five Transformers

or molybdenum through mixtures of copper with tungsten, molybdenum or both, and precipitation hardening or work hardening alloys of copper with cadmium, cobalt, chromium, beryllium, silver and many others. The use of these various alloys with proper water cooling has lowered maintenance costs and increased the life of these parts tremendously. The use of the proper alloy electrode rather than copper is advisable for all resistance welding applications. The makers of these electrodes can advise the proper alloy for a given welding application.

## MISCELLANEOUS

A great many new developments in welding equipment, methods, instruments and accessories are under way at the present time and should be studied so they may be applied where lower costs or a better product may be obtained by their use. A few of them will be discussed.

## THE VANG METHOD OF WELDING

Where condensers are charged with a low value direct current, then discharged directly across the weld forming a short high voltage arc, the energy is capable of making some types of weld of very high quality with practically no upset and very little transfer of heat out of the weld area. This seems to have possibilities of making some welds which are difficult or impossible to make by other methods.

## SCIAKY WELDING

The Sciaky process of spot welding is a form of stored energy welding in which the stored energy is in a reactor instead of a capacitor. After the electrodes are brought down on the work ready for welding, a direct current is applied to the primary of the welder transformer for a period slightly less than one second. The kva. demand is relatively small. After the reactor transformer is energized, the primary circuit is interrupted, allowing the flux to decay rapidly, thereby causing high current to flow in the secondary circuit. I am not qualified to give any opinion of the process.

## WELD RECORDER

There is now available a weld recording instrument which has a deflection which is proportional to $I^2T$ where $I$ is the current and $T$ is the time of current application. Since the heat generated in a resistance weld is proportional to $I^2T$, the deflection of the instrument is approximately proportional to the total amount of heat developed at the weld. This instrument has adjustable limits, such as plus or minus 10%. After adjusting the welding machine for that current and time duration which will produce a satisfactory weld, the weld recorder is adjusted by means of a potentiometer to give normal deflection for this normal welding condition. Each time a weld is made, the instrument will deflect proportional to $I^2T$ and make a record. Simultaneously, the limit of $\pm 10\%$ will be recorded. If the deflection is within the allowable limits, the operator may continue to weld. If the deflection of the instrument is not within the allowable limits, a record will be made accordingly, a gong will ring continuously, and the initiating circuit of the welder will be opened, preventing subsequent welding until such time as an authorized person depresses a push button station.

Failure of the control to time properly, variations in voltage, loose connections, variation in resistance of the work, electrode diameter, pressure or any other part of the welding operation will be recorded in so much as these variables may cause a change in the time of current application or the value of current. This recorder should be very useful, protecting a manufacturer against faulty welding, particularly resulting from variations in voltage, current, failure of the control, loose connections and other electrical variations.

These weld recorders having a deflection proportional to $I^2T$ are far superior to the earlier types which operated on a ballistic principle.

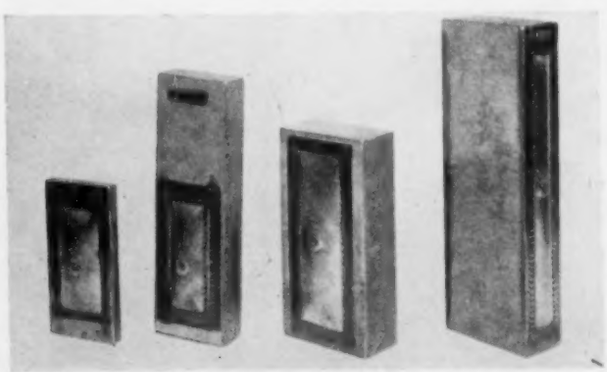

Fig. 8—4 Seam Welds. 0.020-In. to ½-In., 0.020-In. to 1-In., 0.020-In. Each Side of 2-In., 0.020-In. Each Side of 4-In. Steel. Failed at 700, 900, 900 and 1300-Lb. Per Sq. In. (Respectively) Water Pressure

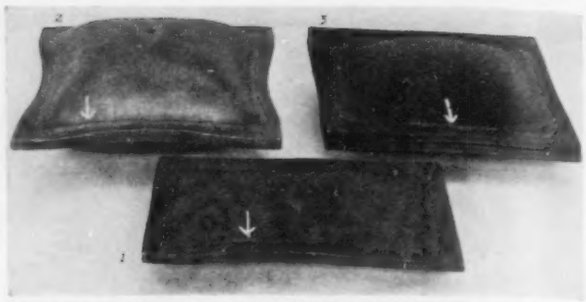

Fig. 9—3 Test Samples of Seam Welds of Steel Plates. Each Broke at Inner Edge of Weld When Inflated by Hydraulic Pressure. 1—Plates 5/16 x 8 x 12 In., Broken at 1400 Lb. Per Sq. In. 2—Plates ¼ x 11½ In. Square, Broke at 2200 Lb. Per Sq. In. 3—Plates ⅜ x 12 In. Square, Broke at 4500 Lb. Per Sq. In.

## POWER FACTOR CORRECTION FOR RESISTANCE WELDING MACHINES

The usual method of correcting the power factor of a resistance welding machine to unity, so as to permit operation of larger welding machines from existing lines is to use a motor generator set. The cost, of course, is appreciable but a very excellent duty is performed by the set, including:

Correcting the load to unity power factor
Balancing the load on 3-phase power systems
Dispersing the load over a longer interval of time than the actual weld by using a flywheel and induction motor (instead of the synchronous motor).

For an individual welding machine, there is a new method available now which will probably be less expensive than a motor generator set, namely, that of using series capacitors.

By series capacitors the demand by spot, projection, or seam welding machine is corrected to unity power

factor, or approximately so, there is a proportional reduction in kva. demand, practically eliminates light flicker, and absolutely prevents direct current components. In applying capacitors it is necessary to have the voltage rating of the supply power and the voltage rating of the capacitor properly matched for successful operation. Precharging of the capacitors to a voltage corresponding to that point on the voltage wave where the thyratron synchronous control will close the circuit provides best operation without any transient current.

### CONCENTRIC CABLES FOR DISTRIBUTION OF POWER IN INDUSTRIAL PLANTS

Frequently the current demand by one welding machine will cause a tremendous voltage drop in the supply line from the supply transformer to the welder transformer. This may limit the capacity of the one welding machine or adversely affect operation of other equipment operating from the same line.

Concentric cables are now available and go a long way toward eliminating this problem. An example of the advantages is as follows:

Let us assume a welding machine which demands 1500 amp. during weld and the distance from the supply transformer to the welder transformer is 300 ft. The supply voltage is 440 volts, 60 cycles. It is desired to furnish power to the welding machine with no more than a 5% drop in this 300 ft. length of cable. If the cables are spaced 5 inches apart, the voltage drop will be more than 5% even though the cable size is 2,500,000 circular mils.

If the insulated cables are in contact with one another for this single phase distribution and the welder operates on no more than a 5% duty cycle, the cables need be only 600,000 circular mils to handle this load. If concentric cable is used, it is only necessary to use 400,000 circular mils.

### ELIMINATING LONG DISTANCE OF LOW VOLTAGE DISTRIBUTION TO WELDING MACHINES

Where there are a large number of welding machines or the total demand of the welding machines in one group is several thousand kva., it is impractical to have several welding machines connected to the same distribution line which may be several hundred feet long. The operation of one welding machine will unfavorably affect the voltage to other welding machines, thereby producing erratic results. In Schenectady a welding shop which demands approximately 2000 kva. RMS load (approximately 4000 kva. connected welder load) is fed by 13,200-volt system coming directly into a Pyranol filled transformer which sits approximately in the middle of the welding floor. The distribution from this 13,200 volt transformer to the welding machine is at 575 volts and the distance in all cases is no more than 40 or 50 feet. With this arrangement the maximum voltage variation at the primary of the welding machine during load or during idle time is approximately ±4%. This is conducive to high quality consistent welding.

### CONCLUSIONS

While a great many valuable developments have been made in recent years in the art of resistance welding, there is still room for a great many refinements in equipment and procedure so that resistance welding may be put on a more scientific basis as many of the developments have had too much of the cut and try method used. It should be recognized that a thoroughly trained supervisory force and skilled operators along with the best equipment available of sufficient size and capacity should be used if full advantage is to be taken of the possibilities of resistance welding.

The tendency in the past has been to let the welding program grow up like Topsy or to let some one who had nothing else to do supervise and operate the welding equipment. An educational program to tell the manufacturing public of the possibilities of the resistance welding process and of the accurate equipment available would be of great value as, to many persons, knowledge of resistance welding is based on the use of an old manually operated spot welder of limited capacity built thirty years or more ago. The writer would also like to urge the closest cooperation between manufacturers of resistance welding equipment and accessories, the users of this equipment and the AMERICAN WELDING SOCIETY, particularly with the various sections of the Welding Research Committee of the Engineering Foundation—sponsored by the A. W. S. and the American Institute of Electrical Engineers, to help develop new test methods, put resistance welding on a more scientific basis and make available educational material.


# 1939 BOUND VOLUME

Bound Volumes of the JOURNAL of the Society for the year 1939 are available with imitation black leather covers. Contains a wealth of information on the latest developments in welding. Also contains Subject and Authors' Index. Price, $5.00 plus postage to members; $6.50 to non-members.

# INDUSTRIAL USES OF PROPANE*

By MESSRS. CLARY, SHEELY and FYKE†

## INTRODUCTION

Propane is one of the more important of the easily liquefied "light fractions" obtained in the stabilization of gasoline which have become known as "Liquefied Petroleum Gases." The commercial use of these gases has rapidly increased. A total marketed production of 165,201,000 gallons was reported by the U. S. Bureau of Mines for 1938. This production is about 36 times the total liquefied gas sales reported for 1928. The simplicity of utilization, availability, uniformity of composition and cleanliness of Propane, make it an ideal gas for industrial use. It is now being successfully utilized in practically every industrial fuel application, in gas and chemical manufacturing, and for many special applications. Propane, known chemically as $C_3H_8$ is marketed by numerous companies under various trade names. The purpose of this paper is to discuss some of the uses of Propane, its advantages and some of the factors pertinent to its successful application based upon extensive laboratory tests and a wide experience in various industrial fields.

## METAL CUTTING

The use of Propane as a cutting fuel for steel is steadily increasing due to its economy both in fuel and handling costs. It is used for this purpose in steel mills, fabricating and manufacturing shops, railroad shops, scrap yards and for erection and dismantling work.

The first step in the use of Propane as a cutting fuel is obtaining the correct flame setting. When lighting the torch, the oxygen valve should be cracked and the gas valve should be opened sufficiently to permit the flame to leave the end of the tip about $^1/_4$ inch. The gas valve should then be gradually closed until the flame is drawn back to the end of the tip and the oxygen regulated to obtain a reducing, bluish green flame about $^3/_8$ inch long. When the high pressure oxygen is turned on no variation in the preheat flame should be observed. The hottest point in the Propane flame, when properly adjusted, is within $^1/_2$ inch from the end of the tip. The metal is most rapidly heated to the oxidizing point when the end of the flame is about $^1/_8$ inch away from the work.

Commercial cuts having sharp corners, smooth sides and a drag sufficiently short to leave no firmly adhering slag, yet completely severing the plate at the end of the kerf, are easily obtained with Propane. In Table 1, below, are given representative cutting speeds, gas consumptions, etc., for plate thicknesses of $^1/_4$—2 inches for machine cutting with Propane, based upon field and laboratory tests in which high quality cuts were obtained.

The variation in oxygen and Propane pressure is due to change in tip size.

In cutting steel plate, the torch should be held in a vertical position for all thicknesses except $^1/_2$ inch or less in which case it should be slightly tilted in the direction of cutting. The same cutting speeds can be used with Propane as used for other fuels. Propane with its high heat value (2518 B. t. u./cu. ft.) has a low fuel and oxygen consumption. The relatively low flame temperature of Propane (approximately 4000° F.) results in very little warping, especially in the thinner sections. Close accuracy in over-all dimensions of the cut part can be obtained, and only small allowances for finishing need be made in the cutting layout. The slag which adheres to the bottom of the cuts is very easily removed due to the reducing flame. The cut surfaces are also slightly softer than usually obtained in gas cutting. When bevel cuts are made the fuel and oxygen pressures are increased slightly over those used for straight cutting. The cutting machine and work should be set up as firmly as possible to eliminate vibration in order to obtain a smooth cut surface.

As a guide in hand cutting, the recommended fuel and oxygen pressures and size of tip are shown in Table 2 for different thicknesses of plate, based on tests in the laboratory and field experience.

Stacks of plates having a total thickness up to approximately $2^1/_2$ inches can be successfully and economically cut with Propane. Stack cutting may be accomplished by holding the plates in position by one or a combination of the following methods: (1) Clamping, (2) Tack welding, and (3) Pressing.

The plates should be clamped as close together as possible and held until the cutting has been completed.

* Presented at Annual Meeting, A. W. S. Chicago, Oct. 23–27, 1939.

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Table 1

| Plate Thickness Inches | Speed Inches Per Min. | Sq. Inches Cut per Cu. Ft. of Propane | Sq. Inches Cut per Cu. Ft. of Oxygen | Drill Tip Size | Propane Pressure Psi | Oxygen Pressure Psi |
|---|---|---|---|---|---|---|
| $^1/_4$ | $33^1/_2$ | 90.21 | 11.03 | 62 | 3 | 25 |
| $^1/_2$ | 26 | 102.05 | 10.43 | 57 | $3^1/_2$ | 30 |
| $^3/_4$ | $19^1/_2$ | 144.30 | 9.71 | 55 | 3 | 28 |
| 1 | $19^1/_2$ | 144.68 | 9.48 | 52 | $3^1/_2$ | 26 |
| $1^1/_4$ | $17^1/_2$ | 141.84 | 9.45 | 52 | 4 | 31 |
| $1^1/_2$ | 15 | 169.27 | 9.41 | 52 | 4 | 35 |
| 2 | $10^1/_2$ | 160.25 | 8.219 | 52 | 4 | 38 |

**Table 2**

| Plate Thickness Inches | Propane Pressure Psi | Oxygen Pressure Psi | Tip Drill Size |
|---|---|---|---|
| 1/8 | 2 | 15 | 57 |
| 1/4 to 5/16 | 2 | 20 | 57 |
| 3/8 | 3 | 25 | 55 |
| 1/2, 5/8 and 3/4 | 3 | 30 | 55 |
| 1 and 1 1/4 | 3 | 35 | 52 |
| 1 1/2 | 3 | 40 | 52 |
| 2 | 3 | 45 | 52 |
| 2 1/2 | 3 | 50 | 52 |
| 3 | 4 | 55 | 52 |
| 4 | 4 | 65 | 42 |
| 5 | 5 | 75 | 42 |
| 6 | 5 | 85 | 35 |
| 7 | 5–6 | 95 | 35 |
| 8 | 5–6 | 105 | 35 |
| 9 | 5–7 | 115 | 35 |
| 10 | 6–7 | 125 | 35 |
| 11 | 7 | 140 | 35 |
| 12 | 7 | 145 | 28 |

If desired, after clamping, welding beads can be run from the top to the bottom of the stack, about 18 inches apart, to hold the plates together. In using either of these methods it is necessary that the plates be as flat as commercially possible. When using a press in connection with stack cutting, a steel plate at least two inches thick is placed on top of the thin plates, about 3/4 inch back from the line of cutting. The pressure is applied at intervals of approximately two feet. In all stack cutting operations, the plates should be clean and commercially free from scale. The purpose of the pressure is to exclude as much air as possible from between the plates. In stack cutting, before the high pressure oxygen is released and the cutting operation commenced, it is necessary to permit the preheating flame to penetrate through all the plates from top to bottom. The cutting operation can then be carried on the same as in cutting one solid piece of steel.

Alloy steel plates, such as 18% Cr—8% Ni and 12% Cr—24% Ni, are being cut with Propane by placing a carbon steel plate, one and one-half to two times the thickness of the alloy plate on top of it. Gas pressures should be higher when cutting alloy plate than usually employed for cutting carbon steel plate of the same thickness. Otherwise, the cutting can then be carried out as in ordinary stack cutting.

Rusty and laminated material such as is found in scrap yards and reclamation departments can be cut very efficiently with Propane. The protection afforded the holes in the end of the Propane tip by its skirt, results in less clogging by flying scale or rust than with open end type tips and consequently fewer back-fires. When cutting rusty material the torch is held at an angle of about 45° in order to burn under and loosen the rust and scale. The movement of the torch should be staggered slightly from side to side when cutting laminated material. Saving in time and labor, therefore, results from the use of Propane because rusty surfaces need not be thoroughly cleaned, and the cutting operation is not retarded by backfires.

Economy is also realized in rivet cutting with Propane largely due to the low fuel costs.

## METAL SPRAYING

One of the newest fields in which Propane offers exceptional possibilities is in the metal spraying industry.

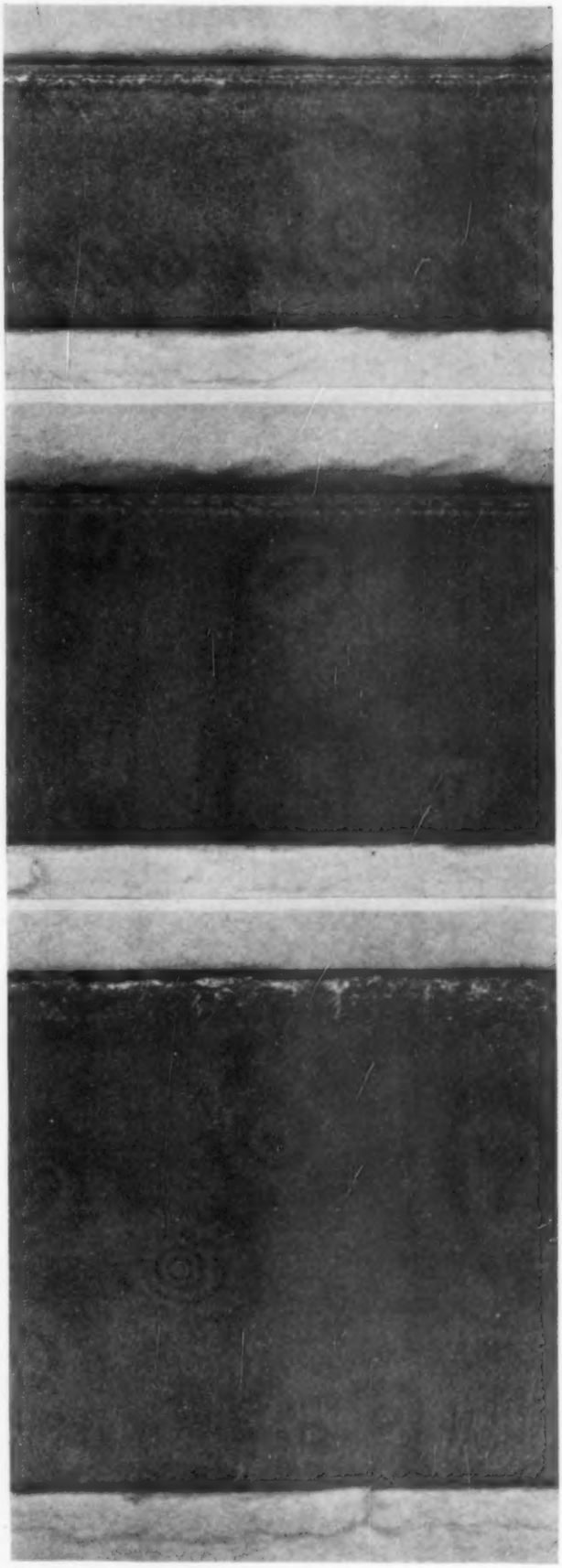

Fig. 1—Top—Enlarged View of Cut of 3/4-In. Plate; Center—1-In. Plate; Bottom—1 1/2-In. Plate

The practicability of using Propane for this purpose, with either wire or powdered metal, has been demonstrated not only in this country but in Europe as well. At least two standard makes of metallizing guns satisfactory for use with Propane are being used in this country. Another type of equipment has been used to a considerable extent with Propane in a metal spraying contractor's shop. Spray efficiencies, the ratio of weights of metal deposited to metal sprayed per square foot, are equal or better than those obtained heretofore. The low flame temperature of Propane results in lower metal loss due to vaporization of the metal being sprayed. Fewer oxide inclusions and a greater density of the deposit, especially with the softer metals, have been reported when Propane was used. A wide range of pressures can be used in metal spraying with Propane. This makes it an ideal gas since it is possible to get just the right speed required for the job. As for any gas, excessively high spraying speeds should be avoided because the corresponding fuel consumption may become uneconomical. When operating continuously, savings, as much as $0.50 per hour per gun, are obtained because of the relatively low cost of Propane. The amount realized, however, is dependent upon all the conditions pertinent to the particular job.

## OTHER INDUSTRIAL USES

Considerable quantities of liquefied petroleum gases are used for industrial furnaces where heat treating or special treating processes are being carried out. Propane and butane are supplied to the ceramic, automotive and metal industries for these purposes. These gases have many advantages such as their economy, freedom from undesirable impurities, availability and safety in handling. Large quantities can be stored in a relatively small space in the liquefied condition. The nonferrous industry uses liquefied gases for bright annealing furnaces because of the exceptionally bright finish obtained. Propane is an ideal gas for carburizing because it is rich in carbon, uniform in composition and free from moisture. This means that uniform carburization can be maintained and for this purpose natural gas Propane is generally used in place of refinery Propane.

The use of gas torches in the preparation of metal surfaces for various services is rapidly increasing. Propane can satisfactorily be used for any of these applications, as for example, the flame hardening of lathe beds and machine parts where wear would destroy the original accuracy and shorten the service life of the part. Structural steel can also be cleaned, descaled and dehydrated with Propane torches. A special multiple-tip torch is made for paint removal.

Brazing, aluminum welding and lead burning are being successfully done with Propane, although its use is not recommended for steel welding at present.

Torches equipped with heating heads are available for use with Propane in spot heating, pipe bending, straightening, shrinking jobs and preheating for welding.

In addition, there are many miscellaneous appliances such as blow torches, soldering irons, etc., which are equipped for use with Propane.

## EQUIPMENT

Equipment manufacturers are realizing the potential possibilities of liquefied petroleum gases; many of them have developed tips for use with Propane. While the efficiencies of these tips vary, and the drill sizes do not always correspond, most of them are satisfactory. In some cases special torches have been developed. The efficiency of injector-type torches, when used with Propane, is further improved by suitable injectors. The only alterations necessary to make existing equipment suitable for use with Propane are the substitution of liquefied gas tips and injectors. All fuel gas regulators are satisfactory for use with Propane. However, metallic diaphragms are considered to be preferable. Suitable nuts and adapters can be obtained where the regulator nuts will not fit the Propane cylinders directly.

## HANDLING

Propane is transported in tank cars, tank trucks and cylinders from the producing plants depending on the size of shipment, handling facilities, etc. The most commonly used cylinder contains about 100 lb. of liquid Propane, equivalent to 859 cu. ft. of free gas. This means fewer cylinder changes and lower handling costs than are obtained with gases in smaller capacity containers. Practically all of the Propane in the cylinder is available for use. Ordinarily, there is no cylinder charge for Propane which especially benefits the small user or job shop although in some cases, a minimum charge has been made where cylinders have been kept for several months. The average plant handling costs of cylinders where Propane is used is reduced as much as from 50 to 60%.

Propane has a narrow inflammability range and high ignition temperature. It is also nonexplosive to shock. The flame is soft and easy on the eyes. Because of the narrow inflammability limits of Propane, air may be premixed in many different proportions without danger of explosion or blow back into the pipe lines. If there is less than 2.4 per cent gas in the mixture, it is too lean to burn and when more than 9.5 per cent is present it is too rich to burn. The regulations and requirements of the National Board of Fire Underwriters and the National Fire Protection Association should be complied with as far as possible in the handling of Propane. Information regarding any special precautions will be furnished by the suppliers.

## SUMMARY

As pointed out in this paper, experience has shown that liquefied petroleum gases are safe and economical as a fuel where a gas is desired and, in addition, their characteristics make them particularly suitable for several special industrial applications.

# WELDING PROPELLER SHAFT TUBING for the Automotive Industry*

By G. C. GRIDLEY†

IN CONSIDERING the part that welded tubing plays in the fabrication of automobiles and other motor vehicles, it should perhaps be mentioned, in passing, that it finds many and varied uses.

An examination of the modern motor vehicle discloses welded tubing to be in use for exhaust pipes, torque tubes, steering columns, tie rods, brake rods, seat frames, and in numerous other places. It is interesting to note that many of these parts were originally fabricated from solids or bars—others from seamless tubing, but at the present time welded tubing of one kind or another is utilized to a great extent.

This is explained, in part, by the fact that in the early days of the automotive industry, welding of any type was considered an unknown quantity and was, in consequence, viewed with suspicion, but as the art of welding progressed, much of this suspicion was dissipated, and it is now reasonably well recognized that it is not an uncommon occurrence for welded parts to display more strength and ductility in the weld than in the adjacent portions of the metal itself. Consequently, the adoption of welded tubing for many of the applications above enumerated.

It will be the purpose of this paper to deal specifically with propeller shaft tubing for the obvious reason that the author's experience has been obtained almost exclusively through a number of years of contact with the manufacture and use of tubing for this particular purpose. Before proceeding further, it may be well to present a brief description of the primary functions of an automobile propeller shaft tube.

In its simplest form, the propeller shaft tube is a piece of tubing of a certain given length, diameter, and wall thickness, to which on one end is welded the front universal joint which is fitted or assembled to the main shaft of the transmission. To the opposite end of the tube is welded the rear universal joint which in turn is assembled to the rear axle pinion shaft. When the vehicle is placed in motion, the power developed by the engine passes first through the various speeds developed by the transmission from which point it is transmitted directly into the propeller shaft through which the driving power is delivered to the differential from whence it passes through the axle shafts to the driving medium, the rear wheels. Consequently, it is apparent that the propeller tube must be capable at all times of carrying full loads developed by the power plant under all conditions.

In the early days of the automotive industry, this function was performed by a solid bar or shaft but as speeds gradually increased and economies in manufacture became important, engineers sought to improve the drive line and reduce cost and weight through the substitution of tubing, and as early as 1914 and 1915, tubes began to appear in place of solid shafts.

The first tubing used was of the seamless type and as small as possible in diameter in order to conserve material. This change caught on rather rapidly with many of the automotive engineers but did not arrive at a successful stage of development without its full quota of engineering problems and manufacturing difficulties.

As early as 1916 our company was asked to have a representative call upon the chassis engineer of a certain customer in Detroit to whom we were furnishing tubular propeller shafts to discuss certain problems that had arisen in connection with our product. Upon arriving at the customer's plant, our representative was asked to take a ride in a car equipped with one of our tubular propeller shafts. The propeller tube in question was made from $1^1/_4$ inch—11 gage tubing and was approximately $46\ ^7/_8$ inches in length. The engineer in charge had cut away a portion of the floor boards directly over the propeller shaft and in the process of riding this car, we were very much surprised to find that at a speed of 55 miles per hour, the propeller tube whipped and swelled until it was describing a circle approximately twice its diameter at the approximate longitudinal center of the propeller shaft assembly. The engineer in charge was naturally very much alarmed and had his mind about made up to change back to the solid type of drive shaft but finally agreed to withhold this decision until further experimental work could be carried out. Among other things, these experiments disclosed that by increasing the diameter of the tube and decreasing the wall thickness, it was possible to obtain a smooth-running propeller shaft free from whip, swelling or vibration at the required speeds.

The theory upon which the above mentioned experiments were based, and the principle evolved from the results obtained therefrom, briefly stated is as follows: The rigidity of the tube increases faster than the square of its diameter; centrifugal force increases directly as the diameter. Therefore, while the centrifugal force, tending to bend the tube goes up directly as the diameter with a given amount of unbalance, its resistance to bending increases faster than the square of the diameter.

This principle of propeller shaft design and manufacture has since been proved repeatedly with the following exception; that due to increased manufacturing difficulties with larger diameters and longer tubes, there is a practical limit beyond which larger diameters and longer tubes do not increase speed possibilities or smoothness of operation.

Prior to this time and on account of the slow speeds required, balancing of universal joints and propeller shafts was a matter that had been given very little thought or consideration, since whatever roughness or out-of-balance might exist in the drive shaft itself, was more than offset and lost sight of due to the noises and

* Presented at Annual Meeting, A. W. S., Chicago, Oct. 23–27, 1939.
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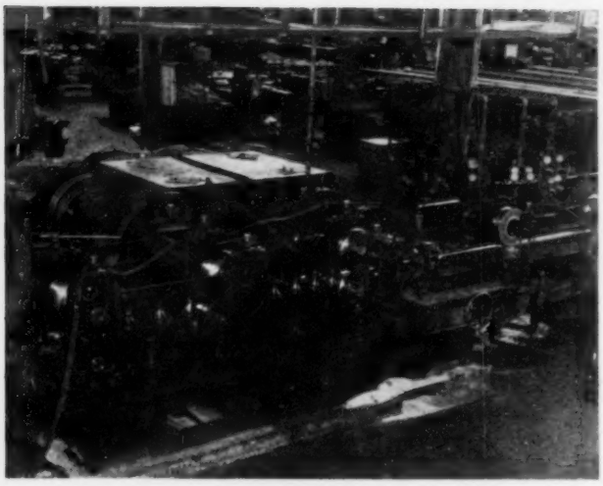


View of Tube Mill

vibrations developed by the engines of the early day. However, as progress was made in the direction of faster and smoother-running automobiles, the necessity for which paced the development and building of our rapidly improving system of highways, there came a time when due to vastly improved and smoother-running power plants, any vibration or out-of-balance in the propeller shaft itself, could be isolated from the rest of the noises or vibrations and consequently came in for its share of comment and criticism.

At about this time, it became necessary for the propeller shaft manufacturer to start casting about for ways and means of improving his product. Most of the automotive engineers had finally been convinced that seamless tubing properly applied had sufficient strength to carry the required loads but were very hesitant in lending their sanction to any experiments that might employ the use of welded tubing for the reason that they were still inclined to look upon the use of a welded part for such an application with suspicion as regarded its strength. On our part, we had discovered that one of the inherent difficulties with the use of seamless tubing for propeller shafts that required better balance characteristics, lay in the fact that seamless tubing as it was then being manufactured, varied in wall thickness at various points on the diameter to such an extent that it definitely affected balance and vibration seriously. A number of experiments were conducted in an attempt to find some good method of overcoming this difficulty, but none proved entirely successful.

In 1920 or thereabouts, we were successful in obtaining permission to try out propeller shaft assemblies fabricated with welded tubing and the results were of such a satisfactory nature that we were permitted to go into the use of this type of tubing on certain applications. At this time we were pursuing the theory that propeller shafts made from tubing welded from strip steel of uniform thickness would run with less vibration at higher speeds than shafts made from seamless tubing, the wall thickness of which was subject to variation. As it then appeared, the only variation that could occur in the wall thickness of the tube so fabricated, would be in and around the weld itself and it was our thought that the isolation and location of this variable would prove much simpler in correction since theoretically it should only be necessary to follow the line of the weld in the straightening and balancing operations, and make the correction either at that point or at a point directly opposite the weld.

In the process of developing this procedure, many interesting phenomena were noted, but the theory was finally proved to be substantially correct and it was not long before practically all propeller shaft tubes we furnished our various customers, where the speed requirements were high, were being fabricated from welded tubing of one sort or another. At first, electric welded tubing was used almost exclusively and while it proved quite satisfactory, we were frequently called upon to defend the theory that the electric weld (as it appeared at that time) was, in reality, not a complete fusion of metals but rather a stitch weld. Many different experiments were carried on at the request of certain individuals with our engineering and operating departments in an attempt to prove or disprove this theory, and while no positive conclusion was reached, the fact remained that there was sufficient uncertainty in the minds of some of our customers to warrant pursuing another line of thought in this regard.

In late 1920 or early 1921, several companies that were manufacturing gas welded tubing called upon us and requested that we try out tubing made by this process and after some discussion we agreed to do so.

Our original experiments disclosed that although propeller shafts made up from oxyacetylene welded tubing ran smoother in our test and balancing machines, the welds were found to be inferior to electric welds and we consequently dared not recommend the use of same for actual service. There was also considerable development work to be done in selecting a steel with the proper physical properties to insure the strength required, since the above tests had been conducted with tubing made of low carbon strip which resulted in a tube that not only would not stand the required torque, but also built up undesirable brittleness in the welds.

After several years of experimenting, during which time great care was given to the selection of the steel and to the improvements of the methods in welding, we had progressed to such a degree that in the year of 1926 we put through a small production lot of propeller shafts built with gas welded tubes which, as far as could be learned, proved entirely successful in the field.

From that time on, we gradually worked into gas welded tubing wherever it was possible—there still remaining certain applications wherein seamless tubing was recommended due to extremely high torques and resulting requirements for a thicker wall. Most of these applications, however, occurred where the speeds were comparatively low so that the matter of balance and vibration was not so vital.

As time went on, we were gradually permitted to change over a large majority of our accounts to the use of oxyacetylene welded tubing with no alarming increase in the amount of difficulties or complaints resulting, and we eventually found ourselves at a point where it appeared advisable to study the possibility of manufacturing our own tubing since our actual requirements were averaging between three and four miles of tubing per day. After due consideration, it was decided to proceed with the development of a tube mill designed to take care of the major portion of our requirements.

As the result of this decision, and after further investigation, early in 1935 we entered into an agreement with the Air Reduction Sales Corporation for the purchase and installation of a mill for manufacturing oxyacetylene welded tubing, and in November of the same year the equipment was in successful operation, and was producing all of our requirements of several of the more popular sizes of tubes.

We were at present operating this same equipment with certain modifications and improvements that have

been added from time to time, and are producing practically all of the tubes we now use in the production of automotive propeller shafts.

In considering the operation of this equipment, I wish to proceed under two main subdivisions which are as follows:

(1) Material and
(2) Method.

## MATERIAL

Prior to the installation of our own mill, we had, as previously stated, been faced with many angles of the problem of developing a satisfactory material for manufacturing good tubing and our chief metallurgist and his staff had conducted many tests and experiments in order to determine what type of strip steel could most successfully be fabricated into the type of tubes required.

Forearmed with the data so obtained, it was possible for us to proceed with the development of the mechanical, chemical and metallurgical properties of the strip steel to be used in the manufacture of tubing.

At that particular period the torsional requirements of propeller shafts we were furnishing were comparatively low, in consequence of which the physical requirements for the strip steel were not nearly as rigid as they later became. The original specification was for S. A. E. No. 1010 steel, cold rolled to three-quarter hard temper (B70-80 rockwell) of the rimmed or semi-killed variety. This type of material welded quite satisfactorily, a fact that was largely due to the slow welding speed that was then being employed. As soon as we attempted to increase welding speeds, certain distinct disadvantages appeared in this material due to the gaseous and other inclusions interfering with sound welds, and thereafter the development of the strip steel was gradual and followed along with improvements made in the welding equipment by merit of which higher welding speeds were attained.

Coincidental with the increase in welding speed, torsional requirements were rapidly becoming higher and in order to meet these new requirements, the strip steel specifications were subject to revision accordingly.

Starting originally with the S. A. E. No. 1010 rimmed steel at three-quarter hard temper, the first change introduced was to S. A. E. No. 1010 silicon-killed steel rolled to the same temper as the original material. This change improved the weldability greatly and all strip steel used subsequently in our plant for the fabrication of propeller shaft tubes has been specified "silicon-killed" and must meet this requirement.

As a result of the increase in torsional requirements, carbon and manganese content for the strip was raised along with the hardness and our most recent specifications call for strip steel corresponding to S. A. E. No. 1020 with the carbon content about 0.20 and the manganese toward the upper limit of the range, approximately 0.60. This steel is processed to full hard temper at the mill and comes to us at rockwell B85-100—depending on the particular size, gage and requirements. So far, this present type of material has demonstrated its ability to be welded satisfactorily at higher speeds

Simultaneous with the development of the chemical and metallurgical properties of the strip, certain changes were introduced into the mechanical properties. Very early in our experience, it became apparent that standard mill tolerances covering gage, width and camber were much too liberal to permit the successful fabrication of good tubing at the higher welding speeds and that closer tolerances in this regard were absolutely essential.

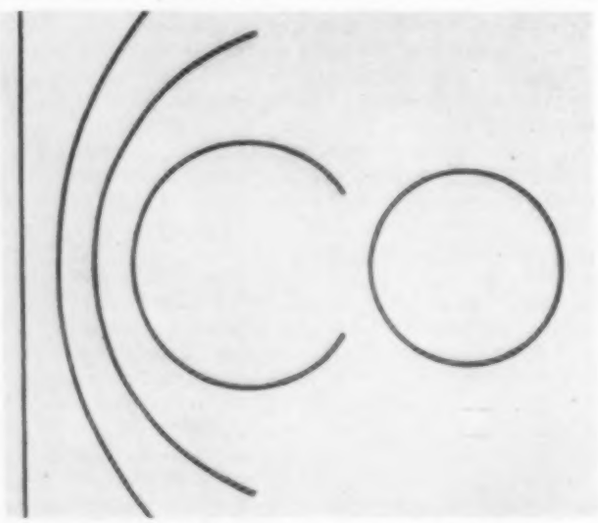
There was very little or no difficulty experienced in obtaining closer control over the width and thickness but considerable difficulty was encountered in obtaining straight steel. The necessity for straightness of the strip is quite apparent in light of the fact that the welding tip in use is approximately 25½ inches long and offers in itself no possibility of assisting the control of the location of the edges of the strip under the flame, all the support being taken at either end of the torch. Furthermore, it would be a physical impossibility for the welding machine operator to attempt to follow the edges of crooked strips with the torch because of the high welding speed.

Consequently, the matter of camber or snake, became a real problem and it was only solved by purchasing strip steel from mills that had the proper set-up to produce steel comparatively free from these undesirable characteristics.

Another interesting development in connection with the material came about in the matter of the size of the coil. It was found advisable in the early stages of the game to keep the coils on the small side in order to facilitate handling, but as the operations on the forming mill and welder attained higher speeds, it became desirable to increase the size of the coils in order to reduce down time for set-up. Up to a certain point this did not present any particular problem to the steel mill, but with the addition of improved handling facilities, we arrived at the point where we required coils as large as they could reasonably be made and handled, and as the result of the very fine cooperation of the various steel mills, we are now being supplied with coils weighing up to 3000 pounds.

It might also be of interest to note in passing that considerable development and experimental work is being done along the lines of attempting to use hot-rolled strip steel in the manufacture of propeller shaft tubes. So far, very little has come of these experiments due to the fact that the hardness of hot-rolled strip is considerably under that found in cold-rolled strip and to date it has not been possible to develop a hot-rolled strip having the necessary physicals and other characteristics required for use in the successful fabrication of propeller shaft tubes.

Our original method of manufacturing tubing consisted of forming the flat strip to a circular shape in a forming machine and welding the seam in a welding machine which was a separate unit. This was necessary due to the inability at that time to attain welding speeds comparable to the speeds which could be obtained from the forming equipment. Forming speeds of 50 feet per minute were entirely practical, whereas our maximum



Cross Sections of Tubing at the Various Stages of Operation

welding speed was 18 feet per minute, which resulted in an undesirable unbalanced flow of production and caused a considerable bank of tubing in process between the forming and welding operations.

Due to this condition, it was necessary to form the tubing in approximately 60 foot lengths, the exact length depending on the dimensions of the finished tube, in order to have a minimum amount of scrap due to crop ends. This length of tubing would engage a signal and the operator would then stop the forming machine and cut off the 60 foot length, employing a swing saw mounted on the front of the machine. This length of tubing was then transported by means of a conveyor rack to a position in line with the welding machine.

Our chief objection to this method was the necessity of shutting down the forming machine in order to cut off the 60 foot lengths. The cutting off operation, coupled together with the lost time involved in placing the length of tubing in position for welding, resulted in loss of production, and, in our opinion, was lost motion.

Further difficulty was experienced when the pipes were put through the welding machine. Approximately 18 inches on each end of the pipe was lost due to the fact that the welds would not hold. The reason for this was that after the welded tube passed through the supporting rolls, the weld was still in a plastic stage and the flare at the end of the tube exerted sufficient pressure to pull the weld apart for this distance. Spoilage resulting from this feature alone reached disturbingly high proportions. Another undesirable factor also existed due to the fact that the pipes, on passing through the welding machine, developed considerable sweep or bow in a downward direction. This sweep was caused by the expansion of the top of the tube at the point where the weld was made. While some of this sweep corrected itself upon the cooling of the weld, a considerable portion of it remained in the pipe and proved to be very difficult to remove in the subsequent straightening operation.

After our mill had been in operation approximately two years, the engineers of the Air Reduction Sales Corporation, who had worked very closely with the builders of the equipment, came to us with the suggestion that we rebuild the forming machine and welding machine into one unit—thereby simplifying the operation and eliminating practically all of the lost time due to shutdown of equipment, and much of the spoilage. This we agreed to do and after considerable investigation on the part of their engineers and ours, the combined forming and welding machine we are now using was developed and installed.

The arrangements of this later machine incorporate a forming operation, welding operation, straightening operation and a traveling cut-off in one unit. This arrangement permits the operation of forming, welding, straightening and the cutting of lengths of tubing to multiples of the finished tube with a minimum amount of shut-down. Shut-downs now occur only three or four times during an 8-hour period and are made necessary by carbon formations on the welding torch which must be cleaned away to prevent plugging of the flame jets. This nearly continuous operation of the machine is made possible by the joining of one end of the coiled strip to the next coil by means of welding with an oxyacetylene torch. During the joining of the two coils together, the form mill is fed by a loop of strip steel that is suspended over the machine in a manner which will be described later in this article. With the equipment as it now stands, our cycle of operations for making propeller shaft tubes is as follows.

The strip is received from the mill in coils of approximately 3000 pounds each. These coils are unloaded from the car into a storage space adjacent to the forming mills and the first step in operations consists of the mounting of the coil on a roller bearing reel. The strip then passes through an arrangement of rolls for the purpose of straightening the effects of coiling. It then passes across a table and through a shear at which point the first end of the strip is squared. The squaring of the end is to facilitate the welding of the new coil to the preceding coil—the latter end of which is likewise squared as it reaches and passes through the shear. The strip then is threaded over a series of large diameter pulleys which carry it upward to a height of approximately 10 feet over the top of the forming machine. It is then passed over a roller which is mounted on anti-friction bearings. This roller is mounted in a traveling shuttle which operates on an "I" beam track and has a possible lateral movement of 120 feet. The traveling shuttle is propelled up and down the track by means of an electric winch and cable, and as the result a loop of steel strip of an approximate length of 240 feet is formed. It is this loop of steel that is fed through the forming mill during the operation of the welding of the ends of the two coils together, that is, while the last end of the preceding coil and the first end of the new coil are being clamped in a stationary position and welded with an oxyacetylene torch mounted on a manually controlled variable speed traverse.

Upon the completion of this weld, the clamps are released and the winch and cable arrangement is actuated, and whatever portion of the overhead loop has fed through the forming machine during the shearing and end welding operations, is returned. This is a very important development inasmuch as it renders unnecessary the shutting down of the form mill and welder during the joining of the two coils together. After this loop is formed, the end of the strip is then threaded through a second series of large diameter pulleys and brought back down to the operating level of the forming machine where the process of forming the tube begins.

The strip then encounters the first set of forming rolls which consists of a heavy convex roll on the upper side working in conjunction with a matching concave roll below. These rolls are mounted in a vertical position and give the strip an approximate 15° radius. From there the strip passes into the first set of conductor rolls which are mounted in a transverse position and consists of three concave rolls on either side of the strip—their function being to assist in the forming by progressively turning up the edges of the stock and also to guide the stock into the second set of breakdown rolls.

The second set of breakdown rolls is very similar to the first except that the arc or radius formed at this point is much sharper than the first. From here the semi-formed tube passes into a second set of conductor rolls which are again found in a transverse position and consists of 4 rolls on either side that still further carry on the progressive forming and guiding of the tube into the final set of form rolls.

The final set of forming rolls mounted in a vertical position consists of two concave rolls that compress the semi-formed tube into its final circular shape ready for the welding.

The tube then passes through the first set of welding rolls which in shape are very similar to the final form rolls with the exception that the top roll has a fin around its central axis, which serves the function of regulating the opening between the unwelded edges of the tube and holding the opening straight and in line with the welding tip. From this point, the tube passes into a second set of welding rolls which support the tube during the preheating stage before welding. These rolls consist of 4 concave rolls mounted in a transverse position. The tube

then encounters a third set of welding rolls which consists of two concave rolls that support and slightly compress the tube during the actual welding operation, which, since it stands out as unquestionably the most important individual function of the cycle, deserves a certain degree of added consideration before passing on to the operations that follow.

The oxyacetylene welding process as applied to seam welding, such as in the tube welding operation, with its lineally extended high temperature heating application, combined with the oxide reducing atmosphere and the lengthwise extended puddle of molten metal, permitting the escape of gases and impurities, augmented by the compression of the plastic metal in the weld, producing a forging effect, insures welds of the highest quality and strength.

The internally localized melting effect in making welds of this type permits the operator to continuously observe the fusing of the metal, the action of the molten puddle in bridging the gap in the seam, the throwing off of impurities and the changing from a liquid to a plastic state. To an experienced operator these various steps in the production of a weld and the modifications that occur from one reason or another, indicate to him rather exactly the value of the weld that is being produced. He has within his reach the various means of modifying or correcting the results to compensate for the changing conditions. His control is by modifying the position and relation of the heating medium to the seam so as to control the amount and location of heat applied, and to govern thereby, the quantity of edge metal melted. In addition, he has physical control of the molten puddle itself by the variation in the amount of pressure which governs the distance over which the edges of the seam are melted, and to the same extent governs the length of the molten puddle, also the amount of pressure that is applied to the plastic metal, thereby controlling the cross-sectional area of the weld produced. By this we mean that by the utilization of one or more or all of the controls available welds of any desired depth of penetration, quality and cross-sectional area can be produced and maintained.

In the combustion of oxyacetylene, as used in this welding method, there is liberated considerable hydrogen which cannot burn in the high temperature reaction and therefore burns freely, picking up its oxygen for combustion to a greater or less extent from the atmosphere, depending upon the method of applying the heat. This envelope more or less surrounds the tube and because of the opening in the seam, ahead of the point where the metal has actually joined into a single puddle, part of the hydrogen is projected down through the seam opening and burns to a limited extent inside the tube, and flows along through and with the tube, blanketing internally the hot metal in the weld, burning at the end as each successive length is severed. With this continuous blanketing, both internally and externally, the metal melts, solidifies and cools to a greater or less extent, while blanketed in a hydrogen atmosphere which reduces to a very considerable extent the tendency to surface oxidation.

In a modern, high production tube welding unit operating by the oxyacetylene welding method, the heat application may extend as much as 30 inches or more along the line of the seam, depending on the speed required and the thickness of the metal to be welded. The forward section of this type of burner, or that section extending in the direction from which the tube is advancing, does not melt metal and therefore an opportunity is afforded to take advantage of the greater heat possible in the combustion of the gases by an increased supply of oxygen which is used to burn some of the hydrogen rather than allow it to pick up all its requirements of oxygen from the atmosphere, thereby securing a greater heat transfer in this way.

The rearward section of the burner or tip, the part that actually produces the weld, is likewise supplied with its own individual torch and mixer, and under the control of the operator the quantity of gases consumed is such that the mixture is more nearly the theoretical proportion of 1:1 to avoid superheating and oxidation of the metal. However, this condition does not hold true over the entire length of the burner because the method of proportioning and mixing the gases is such that regardless of whether one section is adjusted to consume an excess of oxygen and the other section adjusted to consume a different proportion of oxygen and acetylene, there is a gradual variation in the proportion of oxygen and acetylene consumed throughout the entire length of the burner. The forward section consumes less oxygen in proportion to the acetylene burned with each succeeding flame jet in the direction in which the tube is traveling, and the same is true of the rearward section to the point where the final flames playing on the molten metal may or may not be reducing, depending on the grade of material which is being welded. Therefore, by the proper adjustment of the pressure used on both oxygen and acetylene on each of the torches supplying the forward and rearward section of this burner, there can be produced a more or less uniform gradation of heat by reason of the variation in the proportion of the oxygen and acetylene burned at each succeeding flame. These results are accomplished by the method employed in the manufacture of the tips on the mixers which are used to proportion the gases consumed.

The material most commonly used in the manufacture of welded tubing is steel, and steel is relatively a poor conductor of heat, with the result that it is possible to bring the edges of a light wall tube to a state of fusion without permitting the heat to dissipate itself through the tube to any great extent. This is evidenced by the narrow heat lines produced on cold-rolled tubing when welded at higher speeds. Because of this well-known condition it has been found preferable to put the heat in the tube in small increments with a varying space between the zones of heat application in order to allow time for the heat to be absorbed as much as possible in the space between the various zones. As the tube progresses it is gradually brought up to a point where there will have been built up, as it were, a dam on either side of the seam. Further application of heat will cause a more rapid absorption along the edges so that the corners of each edge will begin to fuse. Finally, as the tube progresses, the full thickness of the tube wall is fused and the metal suddenly bridges across into a single puddle where additional heat is applied to maintain a puddle of sufficient length so that full penetration is assured and ample time given for the elimination of impurities. The solidification of the metal occurs into a homogeneous weld which has been produced while blanketed with the hydrogen given off in the combustion of the gases.

Welding under these conditions is done at rather high speeds which vary with the given gas consumption in relation to the thickness of the metal to be welded, and when it is realized that the temperature of the oxyacetylene flame is on the order of 6300° F., it will be recognized that with torches or burners having a great multiplicity of flames, speeds can be reached which are in proportion to the distance over which the heat can be applied to bring the metal up to the fusion point. This brings to mind the fact that for the economical application of the

oxyacetylene welding process at high speeds, the dimensions of the welding machine play an important part.

The weld having been produced, the tube passes through a set of 4 supporting rolls which holds the tube in position during the solidification of the weld and permit the tube to assume a slight out-of-round or egg shape as a relief for expansion.

The final set of two welding rolls returns the tube to its circular shape. It then passes through a set of two concave rolls mounted in a vertical position for accurately sizing the O.D. of the tube and at the same time reducing it from 0.015 to 0.025. This reduction in diameter has a refining effect upon the weld as well as adding strength to the tube through the cold reduction.

The welded tube then passes through a series of vertically mounted and staggered straightening rolls. The rolls remove the tendency to sweep and the tubing comes from these rolls straight to within approximately 0.015 inch or less runout per foot.

The next operation is the cutting of the tubing to lengths of approximately 15 feet, depending upon the multiples of the tube for which the pipe is intended. The tube passes through a rotary cutting head and proceeds until it strikes a trip which is set at the desired length. This trip actuates the chuck in the cutting head causing it to be carried along with the tube during the parting operation which requires approximately 5 feet of travel. After the parting operation is completed, the traveling head engages a trip which releases the chuck and the head is returned to the starting position. The multiple length of tubing rolls by gravity to a burring machine at which point the burrs, resulting from the parting tool, are removed.

The multiple lengths of tubing are then transported by means of a conveyor rack to a swaging machine. This machine is of the hammer roll type. The tube is passed over a mandril mounted on the end of a rod which is slightly longer than the length of tubing. The mandril end of this rod locates the mandril in the center of the swaging head—the opposite end of the rod being supported in a bracket on the same center line as the mandril. Therefore, these tubes are swaged by the external hammer rolls at the same time they pass over the mandril. This arrangement permits the accurate sizing of the I.D. of the tube and at the same time peans down the slight bead on the inside of the tube that remains from the welding operation. The accurate sizing of the I.D. of the tube is necessary in automotive propeller shafts due to the fact that the universal joint end members are machined to a press fit in the ends of this tube. The length of tubing is manually fed through the swaging machine and it emerges from the machine and is received into a V type of support.

The length of tubing is forced along this V support by the next length of tubing coming through the swaging machine, and at the end of the V support is located a straightening machine of the Abramson-Sutton type through which the tubing is pulled by the action of the cross axis rolls and emerges on to a conveyor rack straightened to within approximately 0.005 inch runout per foot from which point it rolls by gravity to a hydrostatic test bench.

At the hydrostatic test bench, the multiple length is mounted between two heads and is filled with water at city main pressures. After the filling of the tube is completed, a valve is opened which permits water to enter at pressures ranging from 2400 to 3500 psi, the exact pressure depending upon required specifications. This is to thoroughly test the weld and is performed 100% on all tubing.

It might be interesting to state in this connection that we have on occasions hydrostatically tested tubes to destruction and have found several instances where the tube gave way at places other than the weld at pressures of 6500 to 6800 psi.

After this test is completed, the tubing is cut to the finished length in accordance with specifications and is then carried by conveyor rack to a final precision straightening operation.

In the manufacture of propeller shaft assemblies, as previously stated, straightness is a very important factor, and it is advisable to straighten the tubes as accurately as possible before the same are delivered into our assembly lines, at which point the end members of our universal joint assemblies are welded to either end. Although it is a foregone conclusion that a certain amount of distortion between the tube and the end members will take place in the welding of these parts to the tube, which, incidentally, is done by automatic electric arc welders, experience has proved that the more perfect the tube is as regards straightness and runout before the arc welding, the less difficulty is encountered with balance after assembly.

In closing, I wish to direct your attention to a poem* written by Edgar A. Guest entitled "The Broken Tube."

We found the car beneath a tree,
"The steering knuckle broke" said he,
"The driver's dead; they say his wife
Will be an invalid for life.
I wonder how the man must feel
Who made that faulty steering wheel."

It seemed a curious thought, and I
Sat thinking as the cars went by,
About the man who made the wheel
And shaped that knuckle out of steel.
I tried to visualize the scene—
The man, the steel, and the machine.

Perhaps the workman never saw
An indication of a flaw,
Or seeing it, he fancied it
Would not affect his work a bit,
And said, "It's good enough to go,
I'll pass it on; they'll never know."

"It's not exactly to my best
But it may pass the final test.
And should it break, no man can know
It was my hand that made it so.
The thing is faulty, but perhaps
We'll never hear it, when it snaps."

Of course the workman couldn't see
The mangled car beneath the tree,
The dead man and the tortured wife
Doomed to a cripple's chair for life.
His chief concern was getting by
The stern inspector's eagle eye.

Perhaps he whistles on his way
Unto the factory today
And doesn't know the ruin wrought
By just one moment's careless thought,
Yet human life is held at stake
By nearly all that toilers make.

While this poem was obviously not inspired by a broken propeller shaft tube, the underlying thought as expressed should, in my opinion, serve to emphasize the solemn responsibility that is ours who are called upon to manufacture parts of this nature for the automotive industry.

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# Tentative STANDARD METHODS FOR Mechanical Testing of Welds

Prepared by Committee on Standard Tests for Welds—American Welding Society

Approved by Executive Committee January 18, 1940

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## FOREWORD

AS FOR any engineering product, the quality of welds depends upon competent inspection and adequate tests. Experience has shown that, in general, mechanical tests to determine their strength and other properties are the least expensive and most reliable tests for the quality of welds. Therefore, they are the tests most widely used. In addition, other tests are used in some cases. No other tests appear likely to replace mechanical tests entirely.

Mechanical tests for welds are similar to the usual mechanical tests for the base metal—plate, tubes, etc., with the changes which have been found necessary to determine the properties of welds. These tests for welds have now been used for a sufficient length of time to indicate quite definitely the properties to be determined and the test procedures which not only give adequate information as to the quality of the weld but are the most practicable for welded fabrications.

Although there is a surprising agreement among welding engineers on the properties to be determined and, in general, the test procedure, there is a wide divergence in the shape and size of the specimens and the details of the test procedure. This considerably increases the cost of making the tests, and decreases the usefulness of the results obtained under different codes and specifications, because they cannot be compared directly. There is no logical reason why for a particular welded fabrication the same size and shape of specimen and the same test procedure should not be used by every one. Standardization in this field has all the advantages to every one concerned that are so generally recognized in other fields and need not be discussed here.

Standardization of the mechanical tests for welds does not necessarily

apply to research. It does apply to all tests during commercial production, i.e., what are often called "routine tests."

In preparing this standard no attempt has been made to promote the use of new or unused tests nor to elaborate the usual test procedure however desirable this might appear from a theoretical or logical viewpoint. These standards are the best compromise which could be found in the expectation that existing codes and specifications could be revised to comply with this standard with the least trouble and expense. If this standard cannot be used satisfactorily it is expected that changes may be necessary but that the changes will be consistent with this standard in so far as practicable. Compliance with this standard is strongly recommended in the conviction that such action will greatly benefit the welding industry.

## GENERAL REQUIREMENTS

### I. Scope

**This standard gives the requirements for the specimens, the testing procedure and the method of obtaining the properties. It is not a specification promulgating required values of the properties. The persons including this standard as a portion of a code or specification for a welded product should state definitely:**

1. **The one or more tests which are required.**
2. **The limiting numerical values of the properties and whether they are minimum or maximum.**
3. **The interpretation, if any, of the properties.**

### II. Testing Procedure

All tests involving the application of a tensile load to a specimen shall be carried out in accordance with the applicable portions of "Standard Methods of Tension Testing of Metallic Materials," A. S. T. M. Designation E-8.

### III. Nomenclature

The terminology used in this standard conforms to the "Standard Definitions of Terms Relating to Methods of Testing," A. S. T. M. Designation E-6, and to the standard of the AMERICAN WELDING SOCIETY, entitled "Definitions of Welding Terms and Master Chart of Welding Processes." The term "soundness" used in this standard means the degree of freedom of a weld from defects discernible by visual inspection of any exposed surface of weld metal. In preparing reports of tests made in accordance with this standard, nomenclature shall conform to the above standards and definitions.

### IV. Etching

Specimens to be tested in accordance with this standard shall be etched for either of two purposes: (1) to determine the soundness of a weld (see Sec. VI, *B*), or (2) to determine the location of a weld.

For tests in which the dimensions of the specimen, the procedure or the results depend upon the location of the weld, the surface of the specimen at and adjacent to the weld shall first be etched with any reagent which makes the boundary between the weld metal and the base metal visible, if the boundary is not already distinctly visible.

NOTE: Some reagents commonly used for carbon steels and low-alloy steels (5% or less of alloying elements) are the following:

*Hydrochloric acid*—Equal parts by volume of concentrated hydrochloric (muriatic) acid and water. Immerse the welds in this reagent at or near the boiling temperature. Hydrochloric acid will etch satisfactorily on unpolished surfaces. It will usually enlarge gas pockets and dissolve slag inclusions, enlarging the resulting cavities.

*Ammonium persulphate*—One part of ammonium persulphate (solid) to nine parts of water by weight. Vigorously rub the surface of the weld with cotton saturated with this reagent at room temperature.

*Iodine and potassium iodide*—One part of powdered iodine (solid) to twelve parts of a solution of potassium iodide by weight. The solution should consist of one part of potassium iodide to five parts of water by weight. Brush the surface of the weld with this reagent at room temperature.

*Nitric acid*—One part of concentrated nitric acid to three parts of water by volume.

*Caution*—Always pour the acid into the water when diluting. Nitric acid causes bad stains and severe burns.

Either apply this reagent to the surface of the weld with a glass stirring rod at room temperature, or immerse the weld in boiling reagent provided the room is well ventilated. Nitric acid etches rapidly. It should be used on polished surfaces only, and will show the refined zone as well as the weld metal zone.

After etching, the weld should immediately be washed in clear water, preferably hot water; the excess water should be removed; the etched surface should then be immersed in ethyl alcohol, removed and dried, preferably in a warm air blast. The appearance may be preserved by coating with a thin clear lacquer.

## DETAILS OF TESTS

### V. Base Metal

If there are specifications for the base metal, the tests of the base metal shall be in accordance with these specifications.

If there are no specifications for the base metal, the tests of the base metal shall be carried out in accordance with the standards of the American Society for Testing Materials. Tensile tests, if any, shall be in accordance with "Standard Methods of Tension Testing of Metallic Materials," A. S. T. M. Designation E-8.

### VI. Weld Metal

*A. Density*

1. *Specimen.*—The specimen, *A*, shall be a cylinder complying with the requirements of Fig. 1, and consisting entirely of metal from the deposited metal zone. If the size of the weld is insufficient, the specimen may be machined from a test plate complying with the requirements of Fig. 2.

NOTE: The density is not an accurate measure of the soundness of weld metal. Voids or slag inclusions, scattered throughout the metal abundantly enough so that on an average straight line scribed on the

metal zone. If the size of the weld is insufficient, the specimen may be machined from a test plate complying with the requirements of Fig. 2.

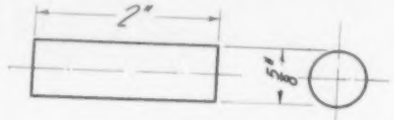



Fig. 1—Density Specimen *A*

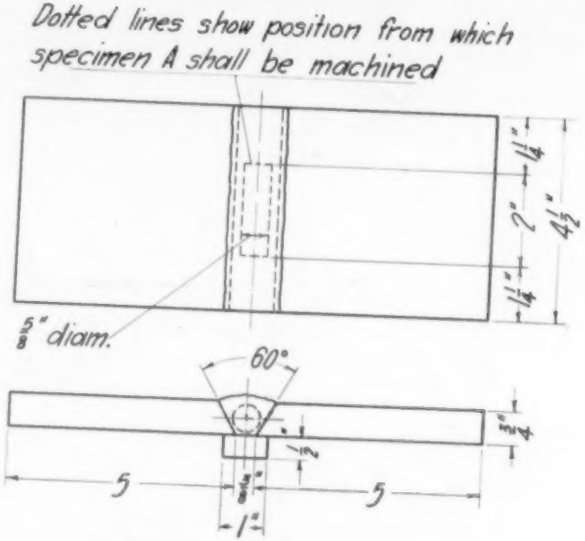



Fig. 2—Test Plate for Density Specimen *A*

2. *Procedure.*—After the specimen has been subjected to room temperature for not less than two hours, the average dimensions shall be measured (screw micrometer) to the nearest 0.0001 inch and the room temperature in degrees Centigrade shall be determined. Using a balance having an error not exceeding 0.0001 gm., the weight of the specimen in air shall be determined.

3. *Results.*—The density shall be computed using the formula:

$$\text{Density, in grams per cubic centimeter} = \frac{\text{weight in air, in grams}}{\text{volume in cubic inches} \times (1 - 0.000033 \times t) \times 16.3872}$$

in which

$t$ = temperature of specimen in degrees Centigrade.
16.3872 = number of cubic centimeters in one cubic inch.
0.000033 = volumetric coefficient of expansion of ferrous weld metal per degree Centigrade.



1. *Specimen.*—The specimen, *A*, shall be a cylinder complying with the requirements of Fig. 1, and consisting entirely of metal from the deposited

NOTE: The density is not an accurate measure of the soundness of weld metal. Voids or slag inclusions, scattered throughout the metal abundantly enough so that on an average straight line scribed on the face of the metal, one-twentieth of the length strikes voids, would result in a change in density of $(1/20)^3$ or one in 8000 (0.012%). To detect such a change calls for high accuracy of measurement. A further difficulty rises from the fact that the normal variations in density between different lots of sound steel may be themselves much greater than one in 8000.

### B. *Soundness: Etch Test*[1]

1. *Specimen.*—A portion of the joint, specimen *B* (no figure) displaying a complete transverse section of the weld shall be removed by any convenient means such as trepanning, flame cutting, drilling or sawing. If removed by flame cutting at least $^1/_8$ inch shall be machined from the face that sections the weld. This face shall be smooth, bright and polished.

NOTE: The face may be filed and polished with abrasive cloth finishing with grade 00.

2. *Procedure.*—The face shall be etched. (See Note, Section IV, for suggested etching reagents.)

3. *Results.*—The etched transverse section of the weld shall be examined for soundness. (See Sec. III.)

NOTE: Persons writing codes or specifications should state definitely their requirements for soundness. Typical requirements are: "complete penetration," "no inclusions," "the number of gas pockets shall not exceed——per square inch," "no gas pocket shall exceed——inches in its greatest dimension," etc.

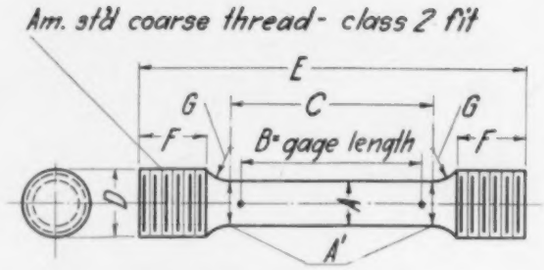
### C. *Tensile Strength*

1. *Specimen.*—The specimen, *C*-1, *C*-2, *C*-3, *C*-4 or *C*-5, shall comply with the requirements of Fig. 3 for the specimen having the largest diameter which can be machined from the welded joint. The portion of the specimen included in the gage length *B* shall consist entirely of metal from the deposited metal zone. The diameter at the ends of the reduced section shall be not less than the diameter at the middle and shall not exceed 101% of the diameter at the middle. All of these specimens are geometrically similar in all significant dimensions, therefore the properties determined from any one of them are approximately the same as the properties determined from any other one, so far as testing technique is concerned.

In the event that filler metal is to be deposited specifically for the purpose of this test, test plates complying with the requirements of Fig. 4 shall be used. The apparatus, materials, methods and rate of depositing the weld metal in the test plate shall, so far as practicable, be the same as those used in making welds with the given filler metal.

NOTE: Due to unavoidable differences in the method of depositing the filler metal and in rates of cooling, the properties of the weld metal

[1] See also Sections VII*A* and VIII*A*.




Dimensions

| Specimen | A (2) | Area (1) | B | C (3) | D | E (4) | F (4) | G (4) |
|---|---|---|---|---|---|---|---|---|
| | in. | sq. in. | in. | in. | in. | in. | in. | in. |
| C-1 | 0.505 | 0.200 | 2 | 2 1/4 | 3/4 | 4 1/4 | 3/4 | 3/8 |
| C-2 | .437 | .150 | 1 3/4 | 2 | 5/8 | 4 | 3/4 | 3/8 |
| C-3 | .357 | .100 | 1.4 | 1.65 | 1/2 | 3 1/4 | 5/8 | 1/4 |
| C-4 | .252 | .050 | 1 | 1 1/4 | 3/8 | 2 1/2 | 1/2 | 3/16 |
| C-5 | .126 | .0125 | 1/2 | 3/4 | 1/4 | 1 5/8 | 3/8 | 3/32 |

A' = (A min., 1.01 A max.)

(1) Cross-sectional area = 0.785 $A^2$

(2) Tolerance, ± 1%

(3) Approximate

(4) Minimum

Note: Dimensions *A*, *B*, *C* and *G* shall be as shown, but the ends may be of any shape to fit the holders of the testing machine in such a way that the load shall be axial.

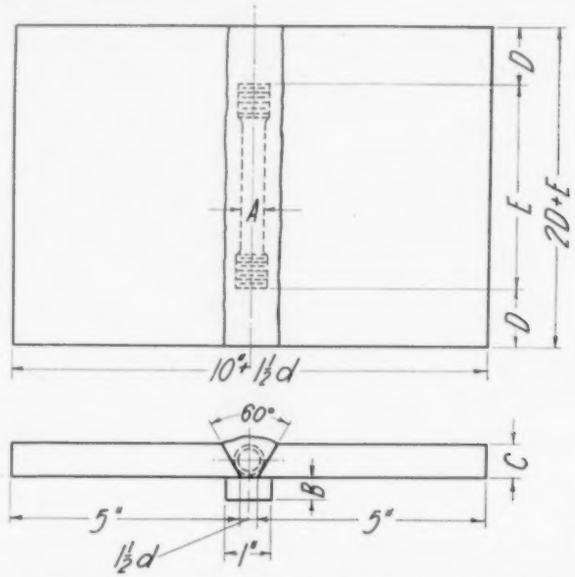
**Fig. 3—Weld-Metal Tensile Specimens *C*-1 to *C*-5, Inclusive**

determined from a specimen will depend upon the dimensions of the adjacent metal.

For thermit welds a suitable refractory material shall be used for a trough in which the weld metal is to be allowed to solidify.

2. *Procedure.*—The diameter of the specimen at the middle of the reduced section shall be measured in inches and the gage length defined by a gage mark at each end. The specimen shall be ruptured under tensile load, and the maximum load in pounds shall be determined.

3. *Results.*—The tensile strength shall be obtained in pounds per sq. in., by dividing the maximum load by the cross-sectional area of the specimen at the middle. The cross-sectional area of the specimen shall be obtained by squaring the diameter of the specimen and multiplying by 0.785. The elongation shall be determined by removing the specimen from the machine, fitting the fractured ends of the specimen together, measuring the distance between the gage marks and subtracting the gage length. The per cent elongation shall be obtained by dividing the elongation by the gage length and multiplying by 100.




d = diameter of filler metal (welding rod or electrode)
Dotted lines show position from which specimen shall be machined

| Specimen | d | A | B | C | D | E | 20·E |
|---|---|---|---|---|---|---|---|
| | in. | in. | in. | in. | in. | in. | in. |
| C-1 | > 5/32 | 0.505 | 1/2 | 3/4 | 1 1/4 | 4 1/2 | 7 |
| C-1 | 5/32 | .505 | 1/4 | 3/4 | 1 1/4 | 4 1/2 | 7 |
| C-4 | < 5/32 | .252 | 1/4 | 3/8 | 1 3/16 | 2 5/8 | 5 |

Note: Test plate may be lengthened as desired to provide for more than one specimen.

**Fig. 4—Test Plate for Weld-Metal Tensile Specimen *C*-1 or *C*-4**

### VII. Butt-Welded Joints

General Statement: Individual specifications may designate which of the specimens described in this section shall be used, and the order in which they shall be cut from any prepared plate or pipe sample. No weld in a plate sample shall be begun or ended nearer than one inch to any portion of a welded specimen taken from that plate.

*A. Soundness: Nick-Break Test*

NOTE: A sharp sudden heavy blow is often specified. There appears to be but little evidence to indicate that there is any appreciable differ-

*A. Soundness: Nick-Break Test*

1. *Specimen.*—For a butt weld in plate, the nick-break specimen, *D*-1, shall comply with the requirements of Fig. 5.

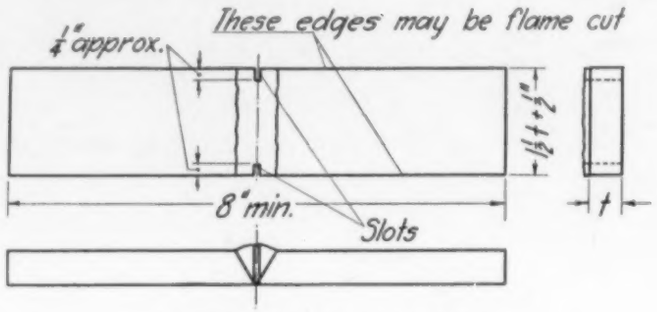



Fig. 5—Nick-Break Specimen *D*-1 (Plate)

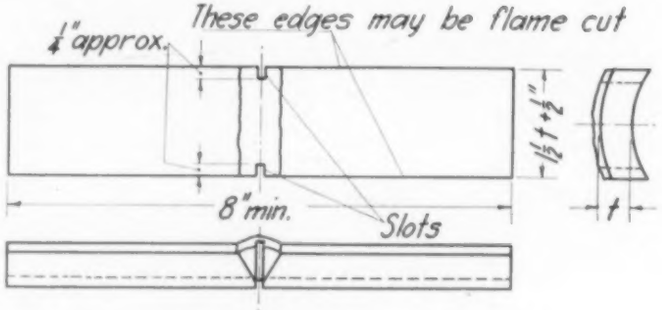



Fig. 6—Nick-Break Specimen *D*-2 (Pipe)

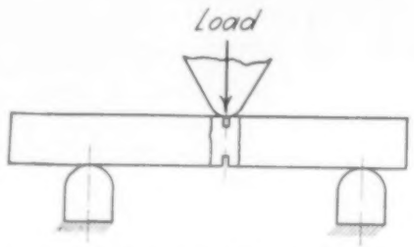



Fig. 7—Method of Rupturing Nick-Break Specimens

For a butt weld in pipe or tubing the nick-break specimen, *D*-2, shall comply with the requirements of Fig. 6.

2. *Procedure.*—The specimen shall be supported substantially in accordance with Fig. 7 and ruptured by a force which, unless otherwise specified, may be applied either slowly or suddenly as by one or more blows of a hammer.

NOTE: A sharp sudden heavy blow is often specified. There appears to be but little evidence to indicate that there is any appreciable difference in the appearance of the fractured surface caused by a difference in the rate of applying the force.

3. *Results.*—The surfaces of the fracture shall be examined for soundness. (See Sec. III and Note, Sec. VI, *B* 3.)

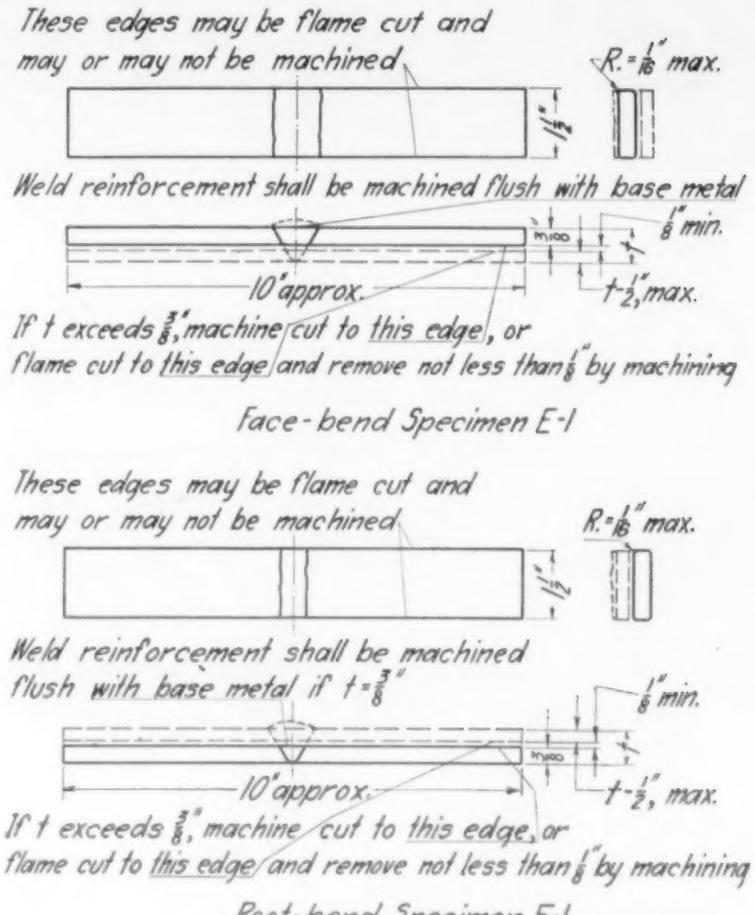
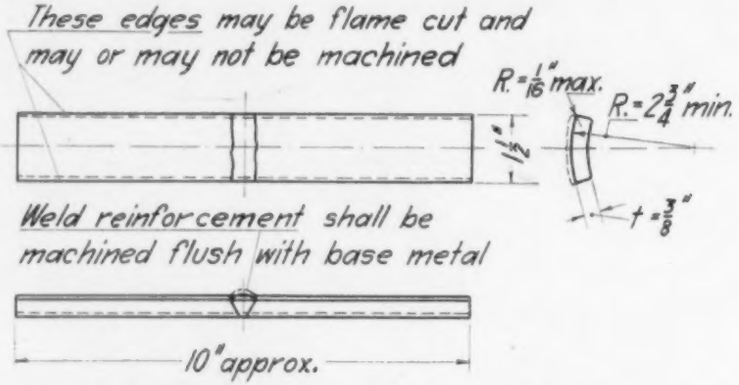

These edges may be flame cut and
may or may not be machined
R. = 1/8" max.
1½"
Weld reinforcement shall be machined flush with base metal
1/8" min.
t
10" approx.
t - 1/2", max.
If t exceeds 3/8", machine cut to this edge, or
flame cut to this edge and remove not less than 1/8" by machining
Face-bend Specimen E-1
These edges may be flame cut and
may or may not be machined
R. = 1/8" max.
1½"
Weld reinforcement shall be machined
flush with base metal if t = 3/8"
1/8" min.
t
10" approx.
t - 1/2", max.
If t exceeds 3/8", machine cut to this edge, or
flame cut to this edge and remove not less than 1/8" by machining
Root-bend Specimen F-1
Note- the face bend and root bend tests are not
applicable if the plate thickness (t) is less than 3/8"

Fig. 8—Face- and Root-Bend Specimens *E*-1 and *F*-1 (Plate)

*B. Soundness: Guided-Bend Test*

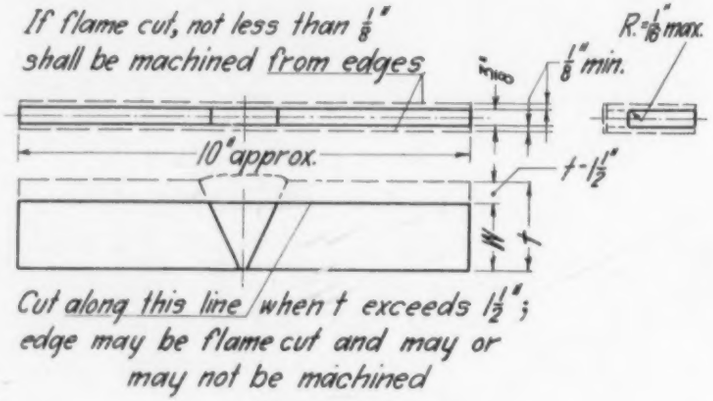
1. *Specimens.*—For welded butt joints in plate, the face-bend specimen, *E*-1, and the root-bend specimen, *F*-1, shall comply with the requirements of Fig. 8.

For welded butt joints in pipe or tubing, the face-bend specimen, *E*-2, and the root-bend specimen, *F*-2, shall comply with the requirements of Fig. 9.


These edges may be flame cut and may or may not be machined
R. = 1/16" max.
R. = 2 3/4" min.
1 1/2"
t = 3/8"
Weld reinforcement shall be machined flush with base metal
10" approx.

Note: This test as now specified is intended for pipe of ³/₈-inch nominal wall thickness only, and is not considered suitable for pipe having a nominal diameter of less than 6 inches.

**Fig. 9—Face- or Root-Bend Specimens, *E*-2 or *F*-2, Respectively (Pipe)**


If flame cut, not less than 1/8" shall be machined from edges
R. = 1/16" max.
1/8" min.
10" approx.
t - 1 1/2"
W
t
Cut along this line when t exceeds 1 1/2"; edge may be flame cut and may or may not be machined

| t, in. | W, in. |
|---|---|
| 3/4" to 1 1/2" | t |
| > 1 1/2" | 1 1/2" |

Note: The side-bend test is not applicable if the plate thickness (*t*) is less than ³/₄ inch.

**Fig. 10—Side-Bend Specimen *G***

The side-bend specimen, *G*, shall comply with the requirements of Fig. 10.

Tool marks, if any, shall be lengthwise of the specimen.

NOTE—Tests have shown that the severity of the guided-bend test increases to some extent with increasing width/thickness ratio of the specimen. Results of the side-bend test are therefore not directly comparable when obtained on specimens *G*, Fig. 10, having different widths *W*.

2. *Procedure.*—Each specimen shall be bent in a jig substantially in accordance with Fig. 11. Any convenient means may be used for moving the male member with relation to the female member.

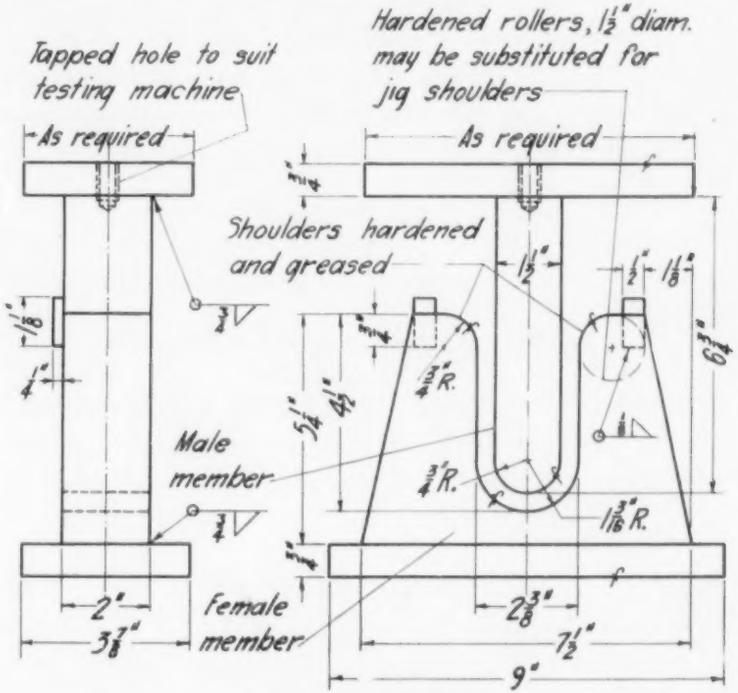



**Fig. 11—Guided-Bend Test Jig**

The specimen shall be placed on the female member of the jig with the weld at midspan. The two members of the jig shall be forced together until the curvature of the specimen is such that a 1/32 inch diameter wire cannot be passed between the curved portion of the male member and the specimen. The specimen shall then be removed from the jig.

Face-bend specimens, *E*-1 and *E*-2, shall be placed on the female member of the jig with the face of the weld directed toward the gap.

Root-bend specimens, *F*-1 and *F*-2, shall be placed on the female member of the jig with the root of the weld directed toward the gap.

Side-bend specimen, *G*, shall be placed on the female member of the jig

For circumferentially-welded butt joints in pipe or tubing having a nominal diameter not exceeding 2 inches, the specimen *H*-5 (full section

Note: The side-bend test is not applicable if the plate thickness (t) is less than 3/4 inch.

Fig. 10—Side-Bend Specimen G

Side-bend specimen, *G*, shall be placed on the female member of the jig with that side showing the greatest defects, if any, directed toward the gap.

3. *Results.*—The convex surface of the specimen shall be examined for the appearance of cracks. Any specimen in which a crack is present after the bending, exceeding a specified size measured in any direction, shall be considered as having failed. Cracks occurring on the corners of the specimen during testing shall not be considered.

*C. Tensile Strength*

1. *Specimens.*—For a welded butt joint in plate, the specimen shall comply with the requirements of Fig. 12, specimen *H*-1, unless in the code or specifications the requirements of Fig. 12*A*, specimen *H*-2, are specifically called for.

NOTE: These two specimens differ only in that in specimen *H*-2 flame cutting of the specimens along the edges is permitted only if followed by machining to a depth of at least 1/8 inch to remove the flame-affected material.

For a circumferentially-welded butt joint in pipe or tubing having a nominal diameter exceeding 2 inches, either specimen *H*-3 or *H*-4 may be used as called for in the code or specification. Specimen *H*-3 shall comply with the requirements of Fig. 13. The ends of the specimen may either be flattened by any suitable means or the ends may be placed in the grips of the testing machine without flattening. Specimen *H*-4 shall comply with the requirements of Fig. 14. This specimen is not recommended for wall thicknesses less than 3/8 inch nominal.

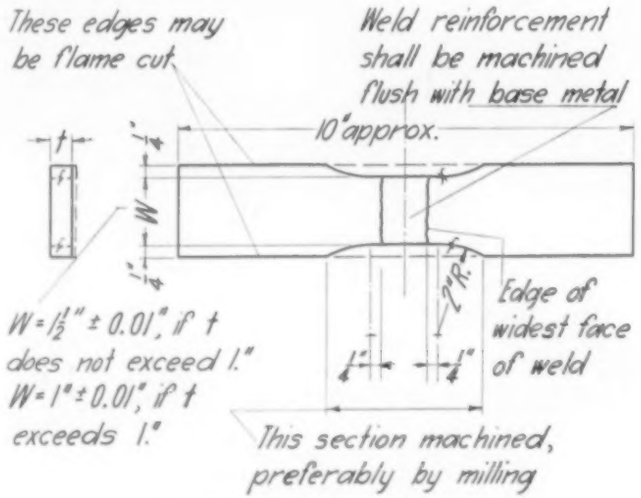

These edges may be flame cut
Weld reinforcement shall be machined flush with base metal
10" approx.
t
W
1/4"
2" R.
1/4"
1/4"
Edge of widest face of weld
W = 1 1/2" ± 0.01", if t does not exceed 1"
W = 1" ± 0.01", if t exceeds 1"
This section machined, preferably by milling

Fig. 12—Tensile Specimen *H*-1 (Plate)

Root-bend specimens, *F*-1 and *F*-2, shall be placed on the female member of the jig with the root of the weld directed toward the gap.

For circumferentially-welded butt joints in pipe or tubing having a nominal diameter not exceeding 2 inches, the specimen *H*-5 (full section specimen) shall comply with the requirements of Fig. 15.

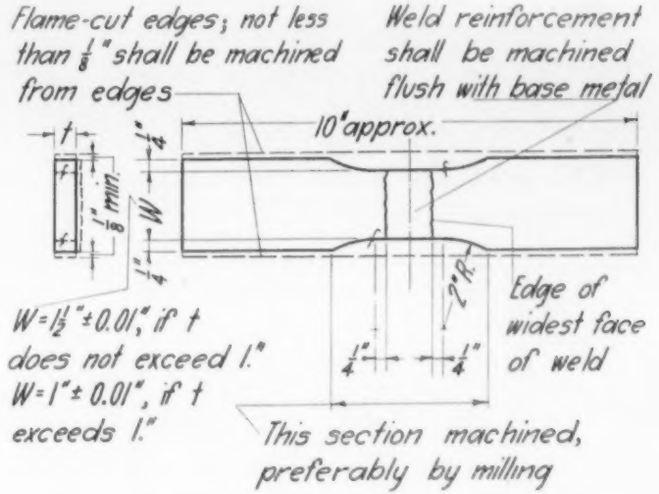

Flame-cut edges; not less than 1/8" shall be machined from edges
Weld reinforcement shall be machined flush with base metal
10" approx.
t
W
1/4"
1/8" min.
1/4"
2" R.
1/4"
1/4"
Edge of widest face of weld
W = 1 1/2" ± 0.01", if t does not exceed 1"
W = 1" ± 0.01", if t exceeds 1"
This section machined, preferably by milling

Fig. 12A—Tensile Specimen *H*-2 (Plate)

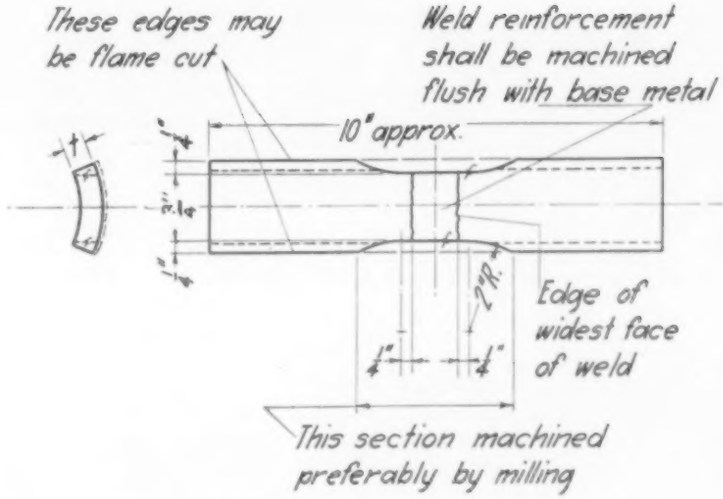



Fig. 13—Tensile Specimen *H*-3 (Pipe)

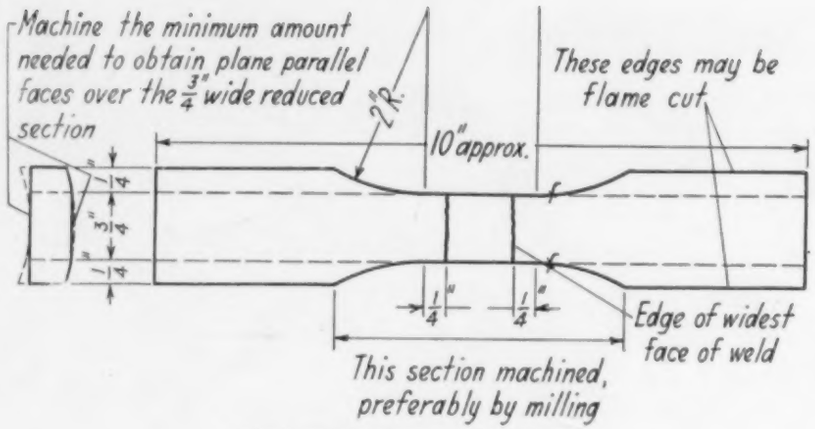



Fig. 14—Tensile Specimen *H*-4 (Pipe)

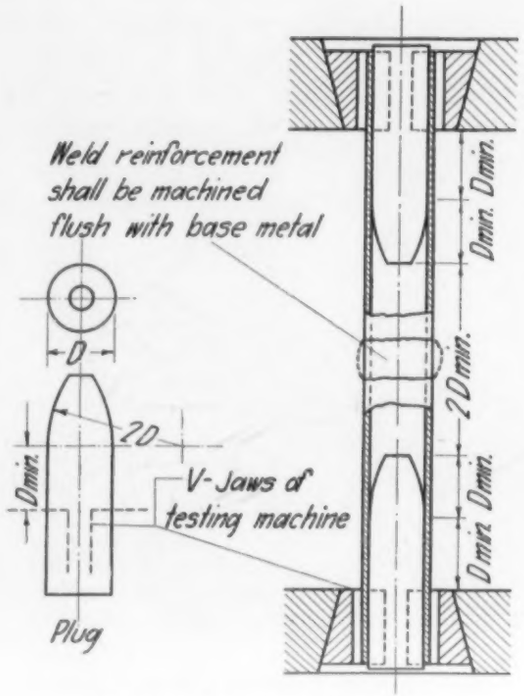



Fig. 15—Tensile Specimen *H*-5 (Pipe)

2. *Procedure.*—For specimens *H*-1, *H*-2, *H*-3 and *H*-4, the least width and corresponding thickness of the reduced section shall be measured in inches. For specimen *H*-5, the average outside diameter, *O.D.*, either at the weld or at a distance not exceeding 1/2 inch from the boundary between the base metal and the weld metal, and also the average inside diameter, *I.D.*, of the base metal at either end of the specimen shall be measured in inches. The specimen shall be ruptured under tensile load and the maximum load in pounds shall be determined.

3. *Results.*—The cross-sectional area shall be obtained as follows:

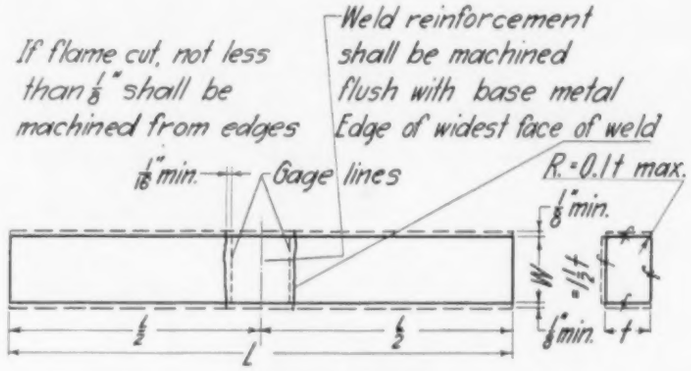
| *Specimen* | *Cross-Sectional Area* = |
|---|---|
| *H*-1, *H*-2, *H*-3 or *H*-4 | width × thickness |
| *H*-5 | $0.785\ (O.D.^2 - I.D.^2)$ |

The *tensile strength* in pounds per sq. in. shall be obtained by dividing the maximum load by the cross-sectional area.

*D. Ductility: Free-Bend Test*

1. *Specimen.*—For butt-welded joints in plate, the specimen, *J*-1, shall comply with the requirements of Fig. 16.

For a circumferentially-welded butt joint in pipe or tubing, the specimen, *J*-2, shall comply with the requirements of Fig. 17.




Dimensions

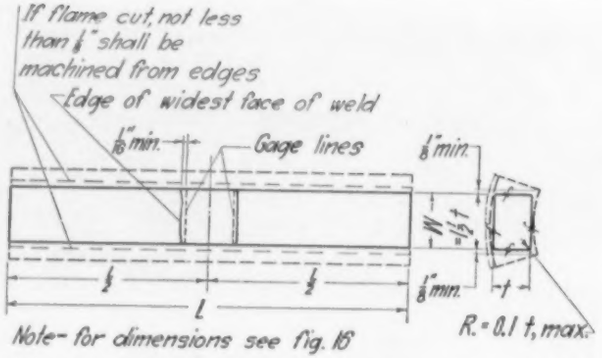
| t, in. | 1/4 | 3/8 | 1/2 | 5/8 | 3/4 | 1 | 1 1/4 | 1 1/2 | 2 | 2 1/2 |
|---|---|---|---|---|---|---|---|---|---|---|
| W, in. | 3/8 | 9/16 | 3/4 | 15/16 | 1 1/8 | 1 1/2 | 1 7/8 | 2 1/4 | 3 | 3 3/4 |
| L min, in. | 6 | 8 | 9 | 10 | 11 | 12 | 13 1/2 | 15 | 18 | 21 |
| B* min, in. | 1 1/4 | 1 1/4 | 1 1/4 | 2 | 2 | 2 | 2 | 2 | 2 | 3 |

* See fig. 18

Note:- the length L is suggestive only, not mandatory

Note: If desired, the edges of the specimen may be prepared by machine flame cutting, followed by rounding of the corners with a file.

Fig. 16—Free-Bend Specimen *J*-1 (Plate)




Note: If desired, the edges of the specimen may be prepared by machine flame cutting, followed by rounding of the corners with a file.

**Fig. 17—Free-Bend Specimen J-2 (Pipe)**



In both cases the width shall be 1.5 multiplied by the thickness of the specimen. Each corner lengthwise of the specimen shall be rounded in a radius not exceeding $^1/_{10}$ the thickness ($t$) of the specimen. Tool marks, if any, shall be lengthwise of the specimen.

If the line between the weld metal and the base metal is not distinctly visible when the specimen is ready for testing, the surface of the specimen shall be etched with a suitable reagent.

2. *Procedure.—Gage Lines:* The gage lines shall be lightly scribed on the face of the weld. The gage length (distance between gage lines) shall be approximately $^1/_8$ inch less than the width of the face of the weld, and shall be measured in inches to the nearest 0.01 inch.

For single groove welds, the gage lines shall be on the wider face of the weld.

For double groove welds, the gage lines on one half the specimens shall be on one face of the weld, and on the other half of the specimens, on the other face.

*Initial Bend:* Each specimen shall be bent initially by the use of a fixture complying with the requirements of Fig. 18. The surface of the specimen containing the gage line shall be directed toward the supports. The weld shall be at midspan of both the supports and the loading block.

*Alternate Initial Bend:* If the purchaser and the vendor agree, the initial bend may be made by holding each specimen in the jaws of a vise with one-third the length of the specimen projecting from the jaws, then bending the specimen away from the gage lines through an angle of from 30 to 45° by blows of a hammer. The other end of the specimen shall be bent in the same way.

In order that the final bend shall be centered on the weld, the initial bends shall be symmetrical with respect to the weld, and both ends shall be bent through the same angle.

*Final Bend:* Compressive forces shall be applied to the ends of the specimen, continuously decreasing the distance between the ends, substantially in accordance with Fig. 19.





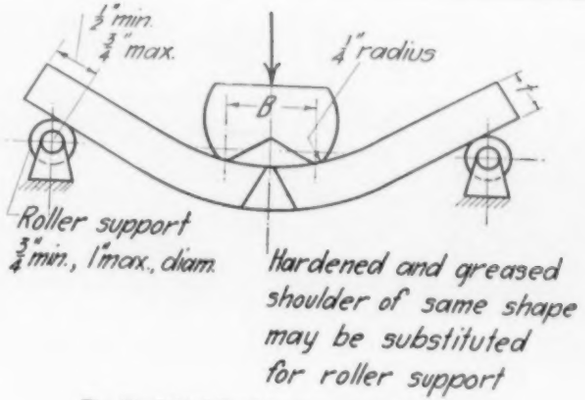



**Fig. 18—Initial Bend for Free-Bend Specimens**

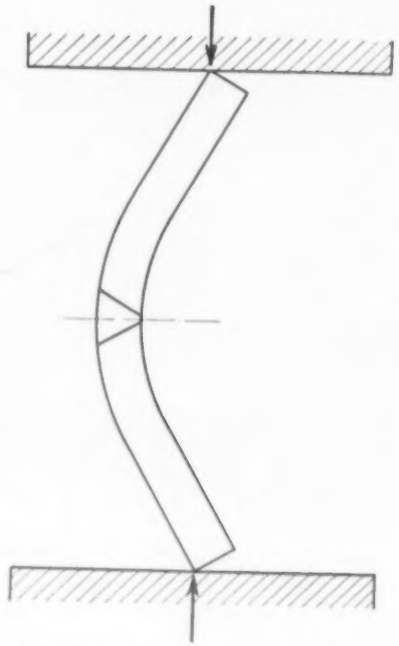


**Fig. 19—Final Bend for Free-Bend Specimens**

NOTE: Any convenient means, such as a vise or a testing machine, may be used for the final bend. The use of a fixture complying with Fig. 20 is recommended. It prevents the ends of the specimen from slipping as it is bent. Life and property may be endangered if the specimen slips.

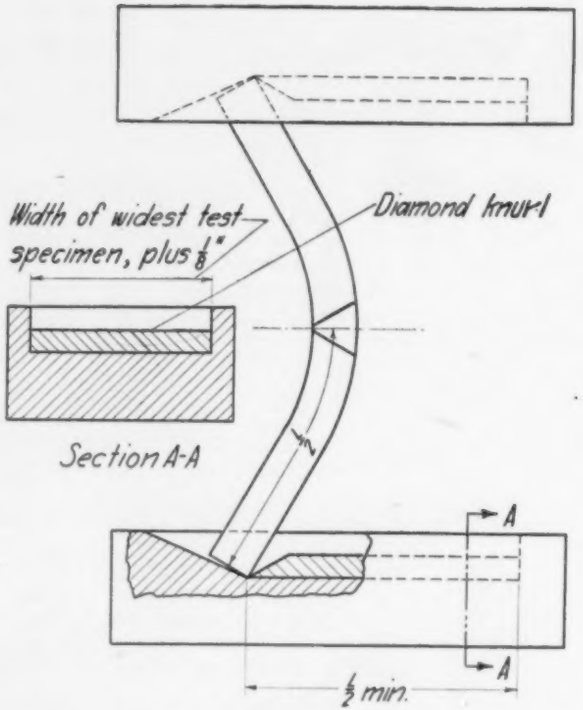



Fig. 20—Recommended Fixture for Final Bending of Free-Bend Specimens

When either a crack or a depression exceeding a specified size in any direction appears on the face of the weld, the load shall immediately be removed. If no crack appears, the specimen shall be bent double. Cracks occurring on the corners of the specimen during testing shall not be considered.

3. *Results.*—The elongation shall be determined by measuring the minimum distance between the gage lines, along the convex surface of the weld, to the nearest 0.01 inch and subtracting the initial gage length. The per cent *elongation* shall be obtained by dividing the elongation by the initial gage length and multiplying by 100.

NOTE: A flexible steel scale graduated in hundredths of an inch and a magnifying glass may conveniently be used when determining the elongation.

## VIII. Fillet-Welded Joints

*A. Soundness: Fillet-Weld-Break Test*

1. *Specimen.*—The fillet-weld-break specimen, *K*, shall comply with the requirements of Fig. 21.

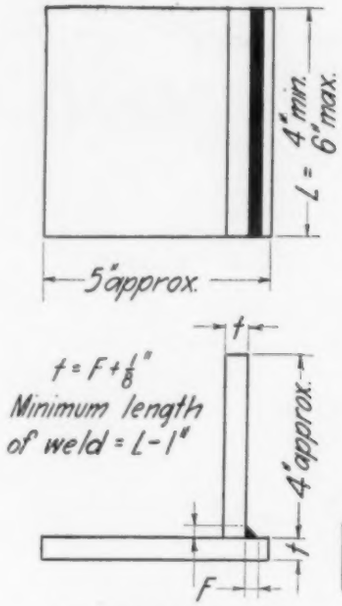



Fig. 21—Fillet-Weld-Break Specimen *K*

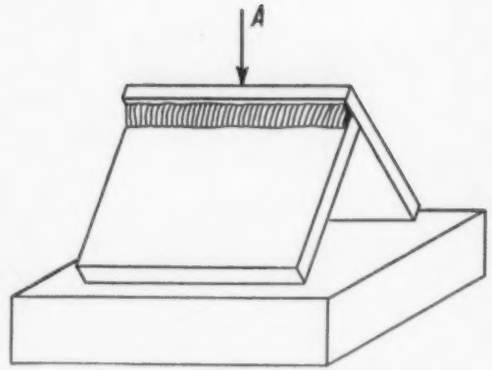



Fig. 22—Method of Rupturing Fillet-Weld-Break Specimen *K*

2. *Procedure.*—A force, *A*, shall be applied to the specimen substantially in accordance with Fig. 22, until rupture of the specimen occurs. The force may be applied by any convenient means.

NOTE: A press, a testing machine or blows of a hammer may be used.

3. *Results.*—The surfaces of the fracture shall be examined for soundness. (See Sec. III and Note Sec. VI, *B* 3).

*B. Shearing Strength: Transverse Welds*

1. *Specimens.—Type A:* The transverse fillet-weld specimen, *L*-1, shall comply with the requirements given in Fig. 23.

*Type B:* The transverse fillet-weld specimen, *L*-2, shall comply with the requirements of Fig. 24.

NOTE: These two types of specimen are currently used for shear tests of fillet welds; type *A*, where comparative rather than absolute value of strength per linear inch of fillet weld is sufficient, and where because of cost or of time limitations it is desired to avoid machining of specimens; and type *B*, where more nearly exact values are desired.

2. *Procedure.*—The width of the specimen shall be measured in inches. The specimen shall be ruptured under tensile load, and the maximum load in pounds shall be determined.

*C. Shearing Strength: Longitudinal Welds*

1. *Specimen.*—The longitudinal fillet-weld specimen, *M*, after welding

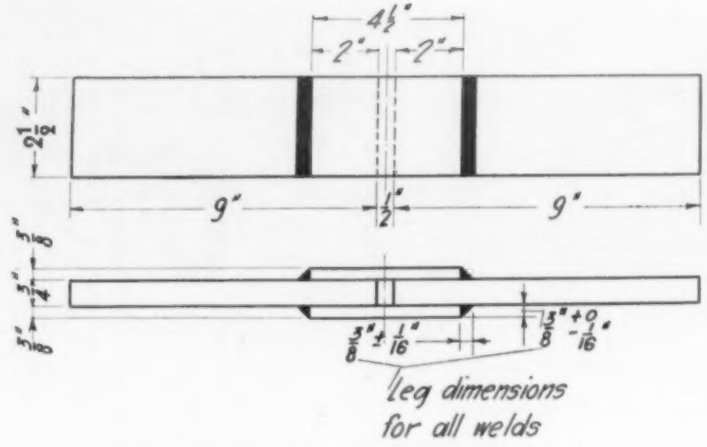



Fig. 23—Transverse Fillet-Weld Shearing Specimen *L*-1

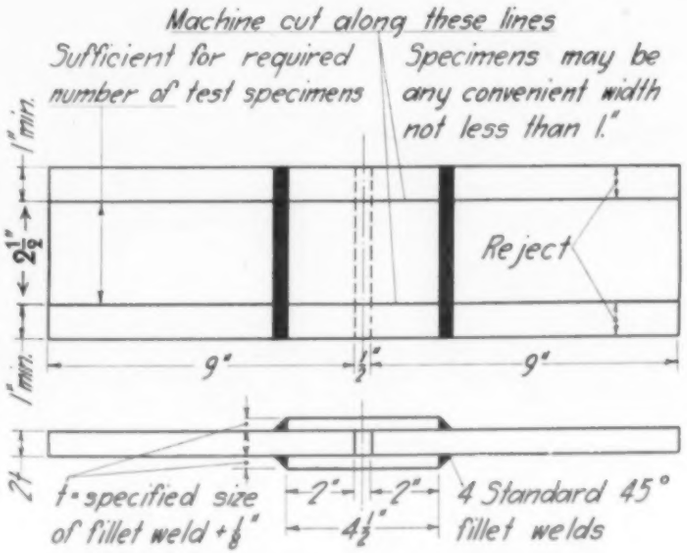


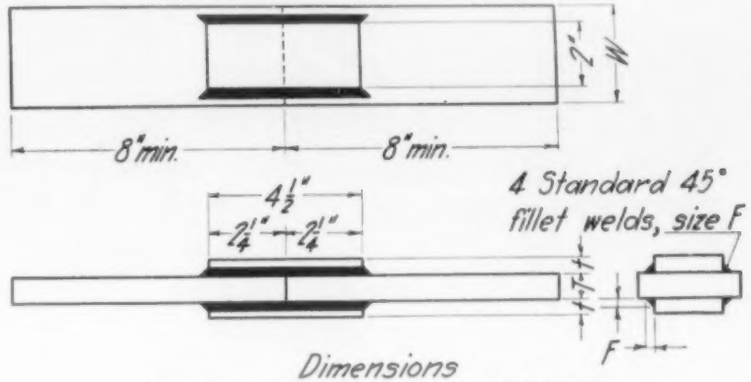

Fig. 24—Transverse Fillet-Weld Shearing Specimen *L*-2

3. *Results.*—The shearing strength of the welds in pounds per linear inch shall be obtained by dividing the maximum force by twice the width of the specimen.

The shearing strength of the welds in pounds per square inch shall be obtained by dividing the shearing strength in pounds per linear inch by the average throat dimension of the welds in inches.

*C. Shearing Strength: Longitudinal Welds*

1. *Specimen.*—The longitudinal fillet-weld specimen, *M*, after welding shall comply with the requirements of Fig. 25 and after machining shall comply with the requirements of Fig. 26.




Dimensions

| | | | | |
|---|---|---|---|---|
| Size of weld F, in. | ⅛ | ¼ | ⅜ | ½ |
| Thickness t, in. | ⅜ | ½ | ¾ | 1 |
| Thickness T, in. | ⅜ | ¾ | 1 | 1¼ |
| Width W, in. | 3 | 3 | 3 | 3½ |

Fig. 25—Longitudinal Fillet-Weld Shearing Specimen *M* After Welding

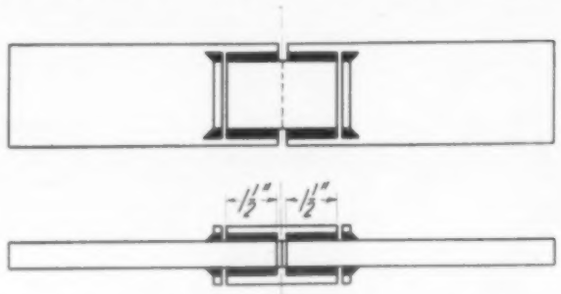



Fig. 26—Longitudinal Fillet-Weld Shearing Specimen *M* After Machining

2. *Procedure.*—The length of each weld shall be measured in inches. The specimen shall be ruptured under tensile load, and the maximum force in pounds shall be determined.

3. *Results.*—The *shearing strength* of the welds in pounds per linear inch shall be obtained by dividing the maximum force by the sum of the lengths of the welds which ruptured.

# THE APPLICATION OF Projection Welding*

By L. H. FROST†

MANY data have been published concerning projection welding, but it might be well to define it. Projection welding may be considered as a process of resistance welding by which a weld is obtained at the desired location by means of an embossment on the part being welded. This means that this method of welding is inherently a production method. Projection welding differs from spot welding in that the embossment, rather than the size of the electrode tip, determines the size and location of the weld.

Since embossments must be formed on one of the pieces being welded, the question arises as to why this method should be used, especially since extra tools and perhaps an extra operation will be required to obtain the necessary embossments or projections. As stated above, projection welding is primarily a production method, so the most important reason for using this method is the increased speed of welding possible. This speed is obtained by multiple projections, which make all these welds with a single operation of the machine. Not only is the speed increased by multiple welding, but also due to the saving of time usually required, in spot welding, for moving the work between successive welds. In addition, the proper use of jigs and fixtures can automatically locate the work more easily than if these fixtures must be moved between successive welds.

Another very important reason for using this method is the dependability or uniformity of results which are obtained. It is obvious that the size and spacing of the welds will be uniform, because they are formed in one of the pieces being welded. The welding dies, or electrodes, can be more easily maintained and will give greater service before resurfacing or replacement, due to applying current and pressure over a greater area. This is very important when running on heavy production.

The type of machine used for this work has all the characteristics of a heavy-duty production machine, and the set-up is more like other production machines, such as punch presses and screw machines.

Like any other production method, there are many factors to be considered. The principal ones to be considered are:

1. The type and location of the embossments.
2. The kind of material to be welded.
3. The type of resistance welding machine to be used.
4. The effect of current, pressure and time on the welding operation.

The type of projection most commonly used is called the button type, and is rounded where it contacts the other piece to be welded. Above 12-gage, these embossments are commonly cone shaped, because of punches and dies required for the forming operation. It is not necessary that the projection be circular, but it is easier to make the forming tools for round embossments and it is generally preferable to use two round projections rather than one rectangular or elongated projection. The actual shape depends upon the nature of the piece being welded. The principal factors to consider are the necessity of maintaining the proper height, as well as equal distribution of current and pressure.

The type of projection depends upon the ingenuity of the designer of the parts to be welded. The important things to remember are that for multiple projections the height of the embossments *must* be equal and uniform, and the size and shape *must* be uniform. A form of this type of welding joins studs to plates, etc. The stud is rounded on the end in contact with the piece to be welded. An ordinary machine screw can be welded by the same procedure. For this application there are available welding bolts having projections formed on the head. These may be on either side of the head, so that they may be attached from either side.

For thin sheet metal, it is evident that the projections may be small. These may be pointed or rounded. If thin sheet metal is to be welded to heavy gage metal, the embossments in the heavy gage metal may be the crater thrown up by a heavy prick punch mark, or any other similar method in which the projections are of uniform size and height.

When welding screw machine parts to light or heavy stampings, the button type of projection is commonly used, since, in this case, it is turned on the heavy piece. A single projection is often used, and, because this must be a heavy projection, some place must be provided for the excess metal. This may be done by undercutting at the base of the projection.

Another form of projection used for this application is in the form of a ring turned on the heavy piece. If production is of sufficient volume the ring projection can be embossed on the stamping and equal results obtained.

In some instances, elongated projections are desirable. Such a case might occur where it is difficult to be certain that proper contact would be obtained. This happens in making a horizontal weld of heavy wire or rod to a stamping. This assures that the wire or rod will have no tendency to roll during the welding operation.

The above merely serves to indicate the variety of shapes and size of projection which can be used. This form of welding permits the designer of parts more latitude than perhaps any other form of production welding.

It must be remembered, however, that in addition to forming the projections these must be in such location that it will be possible to divide the current equally through them. In order to complete the weld, it is necessary to supply pressure for forging as well as the heating to welding temperature, and it is not desirable to have the projections so located that there is possible sliding movement of the pieces during the heating or forging operation. To avoid this, pressure should be applied at right angles to the surfaces of the pieces being welded.

If a few projections, or projections closely grouped, are

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to be made, the question of proper current distribution is usually of small account, but if the projections are widely spaced, or cover a large total area, it is an important factor. Here is one place where experience, as well as common sense, is needed. In addition to the dividing of current, due to the large surface of the welding die, there is a pronounced diversion of the current, due to the magnetic flux produced by the welding transformer secondary leads during the welding operation.

With projection welding, the embossments may be placed at the extreme edge of the piece. If necessary, the necessary embossment may be swaged in from the edge. This is quite different from spot welding, where it is necessary to keep at least the diameter of the electrode tip away from the edge, if uniform, sound welds, with minimum indentation, are to be obtained.

While the above points out the advantages of projection welding, it is all based on the idea that production quantities are sufficient to justify the expense of the tools necessary to obtain the projections, and that a machine of proper type and capacity is available for the work. In many cases, spot welding is the most economical method.

Any metal which can be satisfactorily spot welded, or welded by the resistance process, can be satisfactorily welded by projection welding. Some metals which cannot be satisfactorily welded by the spot welding method can be welded by this method. Some of the copper alloys fall in this group. With these metals, the spot welding electrodes sometimes stick to the work, causing surface mar and increased tip maintenance. Since, with the projection welding method, the current is localized by the embossment, the welding dies have no tendency to stick to the work, as the current density at the contact between the die and the work is much lower than for spot welding. In some cases, cast and extruded metal can be welded in production by this method.

Resistance welding machines for projection welding differ from spot welding machines, principally in current and pressure capacity. Because of the heavy pressures required, machines for projection welding are called "press type" welders. These welders have vertical movement of the head, as compared to the rocker-arm movement commonly used on spot welders. Any spot welder which has sufficient current and pressure capacity could be used for projection welding.

When welding steel up to 16-gage, it is common to figure that roughly 50 kva. will be required per projection. Thus, a job using five projections would require 250 kva. Depending on the rating of the welding transformer, this may be a 100 or 150 kva. transformer. This figure is given only to provide a rough idea of the capacities involved. A machine satisfactory for welding these five projections should be capable of exerting a pressure of 3000 or 4000 pounds.

A machine suitable for this consists of more than a transformer; it must be built as strongly as a punch press. The more careful the design and workmanship, the greater the life and the less the maintenance. For satisfactory service, it must be a machine built for heavy production. For some work, it is desirable to use a machine having a relatively light pressure for heating and a heavy pressure for forging. Such machines are available in both motor-driven and air-operated designs. The usual details of proper current application after pressure has forced the work in contact, proper timing of current and proper time for forging must be provided, as in spot welding.

As in spot welding, there is a definite relationship between current, time and pressure. In general, this balance is not as delicate, because the projections localize the heat and pressure at the proper spot. An excess of current, as compared to pressure, will cause the projections to be melted away before the forging action can take place. An excess of pressure, as compared to current, will give the effect of less current, because the projection will be forced into the work, thus decreasing the resistance at the point of contact. Sufficient time must be allowed for proper heating and forging. This will be similar to that required for spot welding. The current should be cut off at the end of the heating operation and the forging done after this. This is important on very large machines, as the line current may increase materially during the forging operation, if the current has not been cut off. For the five-projection job mentioned, the time would be about eight to ten cycles (based on 60-cycle current).

The factors to consider in the design of parts for projection welding have been mentioned above. The troubles that are encountered in production are traceable either to lack of consideration of these factors or improper maintenance after starting production. After the machine has once been set up it should not be necessary to adjust the timing or pressure or current, provided the line voltage remains reasonably constant. It is very important that a power supply of sufficient capacity be provided. A power supply of widely fluctuating voltage cannot produce uniform welds. Although this is obvious, experience has taught most welder men that this is the first place to look for trouble. Another cause of trouble is pressure. With motor-driven machines, this remains constant, but with air-operated machines the shop line pressure may vary, and it is often necessary to use an air reservoir tank in addition to a pressure regulator. These two factors cause much trouble, which would never have been caused if the machines were properly installed.

As mentioned above, it is very important that the height and size of the projections be maintained uniform. Periodic checking of this point is very important, and a certain amount of maintenance must be expected to maintain the punches as well as the dies. A casual inspection is not enough—they should be checked by gages or indicators.

Perhaps the most important single detail of the projection welding machine is the welding die. These dies serve two purposes, and the characteristics of each function call for opposite qualities in the die material. First, the dies provide a means for passing current through the work. To do this most efficiently requires a metal of the highest electrical conductivity. Such a metal is inherently soft. Second, the dies are used to exert the heavy pressures required for forging. Although the forging is done while the metal is hot, the dies are called upon to withstand pressures sufficient to cause softer metals, such as copper, to flow, especially in the presence of heat.

In some cases, plain copper dies are satisfactory, but in most cases it is desirable, and least expensive in the long run, to use the best material obtainable. For this work, many alloys of copper have been made and are generally available. One new alloy is heat-treatable and air-hardening. Since these alloys cost more than copper, it is common practice to back them up with copper. In addition to serving as a backing material, the copper serves two other functions. First, it serves as a good electrical conductor. This is important, since all copper alloys in common use have an electrical resistance greater than copper. Thus, the copper minimizes current losses and tends to equalize the current. Second, copper is a better thermal conductor than any of its common alloys, and thus serves to carry the heat away from the alloy parts.

For any welding die in heavy production, it is essential that some means be provided for dissipating the heat de-

veloped during the welding process. This is commonly accomplished by drilling passages for cooling water in the copper backing. It is very important that ample cooling water be provided. When properly installed, the great heat-carrying ability of the copper and the water effectively cool the die. This results in increased die life, as well as improved and more dependable results.

Perhaps the most common of all troubles—and this applies not only to projection welding, but to all forms of resistance welders—is neglect of the welding dies. When called in on trouble, the very first place any welder man looks is at the welding dies. Welding dies have a more difficult job to do than forming and stamping dies in punch press work, but seldom receive a fraction of the care or attention given to such dies. The ease with which the welding process is done, and the fact that it is possible to obtain welds under widely varying conditions, has only served to aggravate this lack of attention.

The range of work which can be done by projection welding is very wide indeed, covering nearly all of the common metals and nearly every phase of sheet metal fabrication. Its use, however, is largely one of economics, as it is primarily a *production* process. Projection welding can be applied to heavy or light metal parts, and can make from one weld at a time to dozens of welds at one operation of the machine. Its flexibility is as great as the parts designers' ingenuity.

Future machines will be even more flexible as the art of resistance welding becomes the science of resistance welding. As opinions give way to facts, the machines themselves will be improved and the production facilities of the fastest fabrication method greater than ever.

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# RESISTANCE WELDING CURRENT Measurement*

By E. W. CLARK†

AS THE art of resistance welding has advanced, it has become more and more important that the variables encountered in the process be accurately determined. Among these variables of major importance is the actual welding current, and its measurement is of particular interest.

It is not only desirable but frequently necessary in modern industrial practice to measure the welding current so that experimental welding can be carried on in one department using a variety of machines, and later transferred to the factory where equipment of different construction may be in use. Welding currents on one machine cannot usually be duplicated on another similar machine, by merely setting the welding transformer to the same taps, as often a different secondary circuit or "welding loop" will change the current by as much as 50 per cent, particularly when the throat depth of the welder is changed.

It is not proposed to discuss here the wave shapes which may be encountered in resistance welding, but it is generally recognized that the R.M.S. value of the welding current is the quantity which is the most desirable to measure. Some instruments available for determining welding currents do not measure directly the R.M.S., or effective value of welding current, but it can be easily determined if the welding transformer ratio is accurately known.

Fig. 1—Portable Transformer-Rated Ammeter Type AP-9, With Pointer Pusher for Welding Service. Left-Side and Front Oblique Top View

Fig. 2—Portable Transformer-Rated D-C Ammeter, Type AP-9, with Pointer Pusher for Welding Service. Oblique Top View, Case Raised

Experiments have demonstrated that it is possible to determine accurately the ratio of transformation for the various taps of welding transformers. Once this is done, subsequent measurements to determine the actual secondary welding current can be made by merely measuring the primary currrent and multiplying it by the proper ratio of transformation. The proper ratio of transformation can be easily determined by the use of a shielded transformer and ammeter connected in the secondary circuit of the welding machine, and at the same time reading the primary current by a split core transformer and ammeter connected in the primary side of the welding transformer. By energizing the machine and taking simultaneous readings of the primary and secondary currents, the ratio of transformation is readily obtained.

On welding machines of high rating, it is often impracticable to leave the primary circuit closed for a sufficient length of time to allow an ordinary indicating instrument pointer to come to rest (one or two seconds usually required). In such a case, conventional ammeters, each modified to include a micrometer pointer adjuster like

* This is one of a series of articles being sponsored by the Resistance Welder Manufacturers Association.

† Instrument Engineering Section, West Lynn Works, General Electric Company.

Fig. 3—Typical Split-Core Transformer for Welding Transformer Primary Current Measurements

shown in Figs. 1 and 2, can be used to advantage with successive readings being taken and adjustments made until the pointers indicate the correct currents by just moving away from their stops when the current is applied. Such instruments measure R.M.S. values of current. The micrometer pointer pusher ammeter is named the pointer stop ammeter and was developed especially for use in connection with spot welding machines.

Once the ratio of transformation is determined for the various taps, it may be used thereafter without the necessity of further checkup, since the measurement of primary current multiplied by the ratio factor will always give the current flowing in the secondary of the welding transformer. Examples of work which has been successfully transferred from one machine to another by this method are shown in Figs. 4 through 7.

The ratio of primary and open-circuit secondary voltages may in many cases be used to determine the ratio of current transformation. However, in a number of cases, due to saturation, or some other characteristic of the transformer, the accuracy of the value determined by this method may not be adequate. This method of measurement is also limited to some extent by the characteristics of the voltmeters of low voltage rating which must be used to measure the open circuit secondary voltage of the transformer.

In order to investigate the accuracy of the pointer stop ammeter method, tests have been made under actual welding conditions, with a typical setup being as shown in Fig. 8. These tests included operating under both manual and thyratron synchronous control and the making of oscillograms of various currents. A representative oscillogram is shown in Fig. 9, where curve 1 is the welding current using a shunt in the secondary, curve 2 the

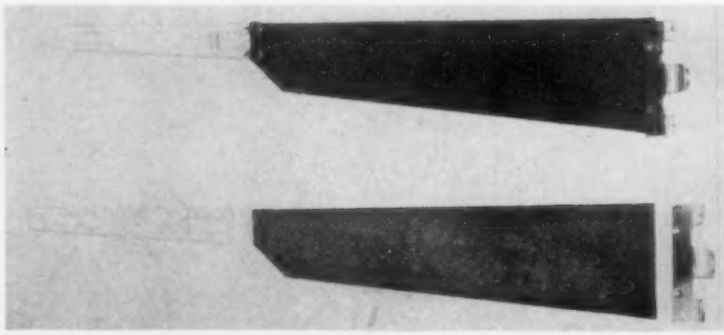


Fig. 4—Welded Single-Blade Thermostat

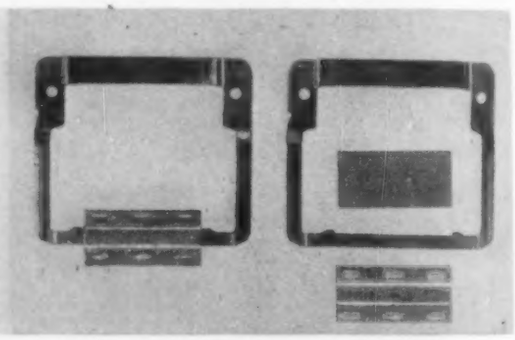


Fig. 5—Welded Compensator for G-E Watthour Meter

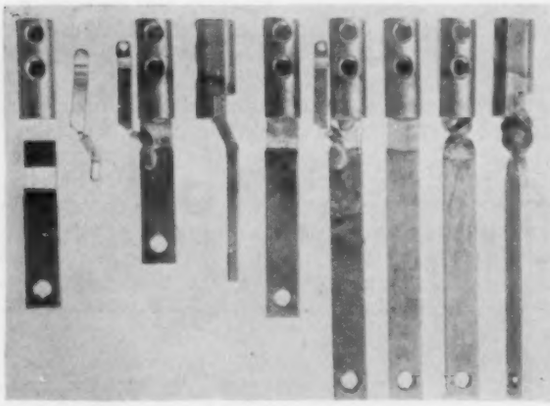


Fig. 6—7 Meter Terminals Brazed on Welding Machine with Definite Control. For G-E Watthour Meters, Type V-3

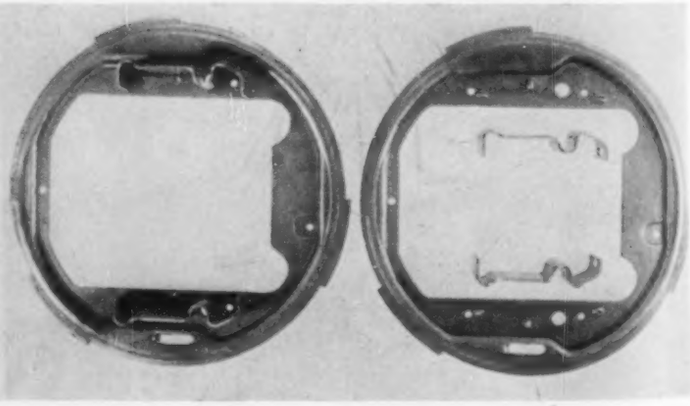
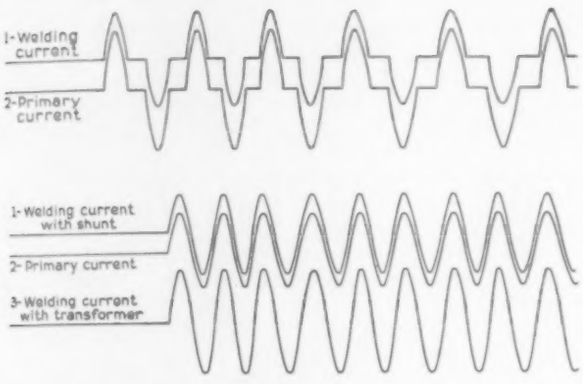


Fig. 7—2 Samples of Welded "S" Base and Spacer

Fig. 8—Welding-Current Measurement by Oscillograph and Special Shunt




Figs. 9 and 10

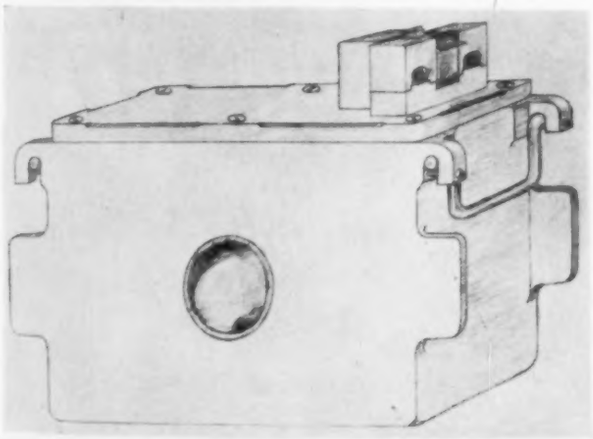


Fig. 11—G-E High-Capacity Current Transformer, 50,000 to 5 Amperes for Measuring of Welding Current. Perspective Pencil Sketch

primary current of the welding transformer, and curve 3 the welding current as measured by an oscillograph and a special current transformer designed for encircling the welder electrode. Figure 10 shows wave shape with reduced heat by the phase-shifting method. The transformer, Fig. 11, was of the shielded type and particularly suitable for operation within the very high strength, non-uniform magnetic field existing near the electrodes in the secondary circuit of the welding machine.

Fig. 12—G-E Water-Cooled Shunt for Use with Oscillograph for Determining Welding Current

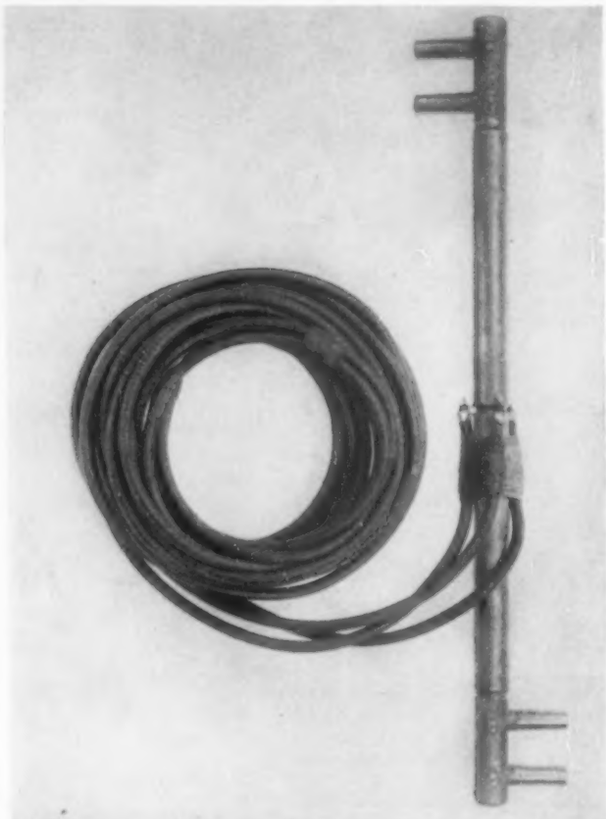


Fig. 13—Pointer-Stop Ammeter Set Up for Measuring Welding Currents of Short or Long Duration for Exact Duplication of Set-Up

To further check the welding current, a special water-cooled non-inductive shunt as shown in Fig. 12 was pro-

vided. Concentric cable was used for the drop-leads from the shunt to the oscillograph to minimize the errors due to induced voltage in them caused by the high magnetic flux density from the large welding currents. Three sets of drop-leads, spaced uniformly around the shunt, were employed, so that any non-uniformity of current density in the shunt (which might be caused by the high flux densities due to the large welding currents) would average out in the final current calculations. This special shunt made it possible to measure welding currents directly on the oscillograph without the use of intervening transformers. Successive measurements of this type gave results within 5 per cent, and the readings obtained were in very close agreement with those obtained by other methods.

While the above tests were being made with the oscillograph, corresponding current values were being measured by means of pointer stop instruments and transformers located in both the primary and secondary circuits. Table 1 shows a typical set of tests results obtained on a standard 25 kva. welding machine. It should be noted that some currents involving phase-shift heat control were studied. This method of control was adopted for parts of the tests since it involves the measurement of currents where there is no particular relation between the peak and R.M.S. current values.

**Table 1—(#)Welding Current (Steady State—Over 30 cycles) as Determined by**

| Special Shunt and Oscillograph* | AP-9 Ammeter and† Special Secondary Transformer | AP-9 Pointer Pusher‡ Ammeter and Standard G-4 Primary Transformer |
|---|---|---|
| 8,150 | 7,750 | 7,990 |
| 13,000 | 12,500 | 12,650 |
| 19,700 | 19,640 | 19,800 |

* Expected accuracy ±5%
† Expected accuracy ±2%
‡ Expected accuracy ±5%

(#) When a conventional AP-9 Pointer Stop Ammeter is used on a short duty cycle, namely, 3 to 10 cycles on a 60 cycle circuit, a correction factor must be applied to the reading obtained to obtain a true current reading. The necessary correction factors are indicated in curve Fig. 14.

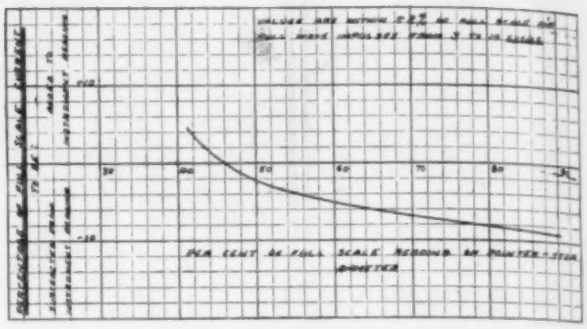


Fig. 14—Response Curve of Pointer-Stop Ammeter

The results of the above tests demonstrate clearly the accuracy of the measurements that can be secured by using relatively simple apparatus, and the availability of these instruments should encourage more widespread determination of welding currents as a routine procedure. It should be noted that the adjustable pointer instruments are not necessarily restricted to the measurement of welding currents, but can be used for regular routine testing by merely adjusting the stops so that the instruments may be used in a conventional manner. For permanent installation, switchboard instruments are available with the adjustable pointer stop. A typical installation is shown in Fig. 13.

Pointer stop voltmeters, either switchboard or portable, are available for measurement of the dip in line voltage when a weld is made. Such information is important if two or more machines operate from a common supply, or if a single machine is used under conditions of excessive voltage drop, thereby limiting its capacity. A measurement of voltage dip should be made for each machine to determine the voltage drop it causes in a line which is supplying other welders.

# Society's Members and Friends Honored

THE rôle of the American inventor and research worker in creating new jobs and raising the American standard of living by developing new products was acclaimed Feb. 27th by 1500 members and guests of the National Association of Manufacturers dining at the Waldorf-Astoria. One hundred and one of these inventors hailed as "modern pioneers" received scrolls of honor in token of distinguished accomplishments.

Following are some of the inventors and research workers in the New York area to whom scrolls were presented last night:

FREDERICK M. BECKET, consultant, Union Carbide & Carbon Corp., New York: His contribution to the field of large scale, low cost manufacturing of ferro-alloys of greater purity have been credited with assisting in a large measure in developing modern steels.

WILLIAM DAVID COOLIDGE, of Research Laboratory, General Electric Co., Schenectady, N. Y.: A physical chemist, inventor of ductile tungsten and of a new and improved X-ray tube.

GANO DUNN, The J. G. White Engineering Corp., New York: Recently awarded the Hoover medal for a quarter-century of service to the government, to science and engineering, to education, civic betterment and to international organization.

CLAUDE J. HOLSLAG, Electric Arc Cutting and Welding Company, Newark, N. J.: His work in producing the alternating current welding transformer and covered electrodes has brought him wide recognition.

DR. DAVID SCHENCK JACOBUS, The Babcock & Wilcox Co., New York: Has been granted 188 patents since 1911 on his inventions in boilers, furnaces, superheaters and other power plant apparatus.

DR. IRVING LANGMUIR, General Electric Company, Schenectady, N. Y.: Holds sixty-five patents in uses of electricity, outstanding being the gas-filled incandescent lamp used for most of the electric light throughout the world; also atomic hydrogen welding torch.

LEON S. MOISSEIFF, New York: Suspension bridge expert who has been engaged upon problems of construction of most of America's great bridges.

WILLIS R. WHITNEY, General Electric Co., Schenectady, N. Y.: Was a pioneer in establishing the modern type of ndustrial research laboratory. He is responsible for a great deal of the improvement in electric lighting and in power transmission.

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# Welding Society ACTIVITIES—Related Events

## 1940 INTERNATIONAL ACETYLENE ASSOCIATION CONVENTION TO MEET IN MILWAUKEE

New York, January 24th.—The 40th Convention of the International Acetylene Association is to be held in Milwaukee, on April 10th, 11th and 12th, it was announced at the Association's office here today. Convention Headquarters will be at the Schroeder Hotel.

In announcing the selection of Milwaukee for this year's convention, the Secretary of the Association said that this city was chosen by the Officers and Directors because of its importance as an industrial and scientific center. Milwaukee is the home of a number of important and diversified industries, and is, of course, within convenient distance from other important industrial centers such as Chicago, Detroit, St. Louis, Cleveland and Indianapolis. Consequently, it was said, a record attendance of engineers, industrialists, and shop technicians is expected. Last year the meeting was held in Houston, Texas.

The program will include a scientific forum on oxyacetylene cutting of metals, a series of round-table discussion meetings, and, on each of the three days of the convention, a group of technical sessions, at which will be presented many interesting papers by outstanding technical men and experts in applications of the oxyacetylene process of welding, cutting and heat-treating. Announcements of subjects and speakers are to be made at an early date.

---

## QUESTIONNAIRE FOR SOCIETY HEADQUARTERS FILE RECORDS

The SOCIETY frequently has need for information concerning certain classes of members on which the records at Society Headquarters are not as complete as might be desired. For this reason the Sections are being asked to cooperate in compiling this information, by means of three questionnaire forms which are being sent out to the chairmen of the Sections. These questionnaires are described briefly below:

(*a*) *Personnel for Committee Work:* The SOCIETY is constantly in need of new talent to serve on its numerous technical committees, and also on its standing and special committees such as legislative, safety, membership, ways and means, and the like. The questionnaire forms provide a convenient and uniform means of furnishing Society Headquarters with the necessary information concerning members who are able and willing to assist in such work.

(*b*) *Consulting Engineers:* The SOCIETY occasionally is requested for information concerning consulting engineers, and in some cases has not been able to render the best of service because of lack of information. Questionnaires in the form of file record cards have therefore been printed, to enable the consulting engineer to have his record placed on file at Society Headquarters. The information asked for on the questionnaire is not intended for general distribution, but will be regarded as confidential and used solely as a guide for the office to intelligently answer inquiries. It is believed that consulting engineers will find it advantageous to fill out the questionnaire as completely as possible.

(*c*) *Welding Fabricators and Job Shops:* From time to time the SOCIETY receives requests for the names of welding fabricators or job shops in given localities that are competent to do certain classes of work. The people who make these inquiries frequently ask for detailed information as to the experience and equipment of a given shop. In order that Society Headquarters may have this information readily available, questionnaires in the form of file record cards have been printed, and are to be filled out by the welding fabricators and job shops.

---

## INSTRUMENTATION IN INDUSTRY

A three-day conference and exhibition will be sponsored by the Power Maintenance Association of South Jersey, to bring to industry in the Philadelphia, Trenton, Camden and South Jersey area an exhibit to show the proper use of instruments to enable industry to minimize production, process and operating costs.

All leading instrument manufacturers will participate and exhibit their newest refinements of instruments for industrial application.

The exhibit will be held March 12, 13 and 14, 1940, in the gymnasium of the Camden County Vocational School, Camden, New Jersey.

---

## A. S. T. M. MEETINGS

1940 Spring Meeting, March 6th, Hotel Statler, Detroit, Mich.

A. S. T. M. Committee Week—March 4th to 8th, inclusive, Hotel Statler, Detroit, Mich. Symposium on New Materials in Transportation.

1940 (Forty-third) Annual Meeting, June 24th to 28th, inclusive, Chalfonte-Haddon Hall, Atlantic City, N. J.

---

## PREDICTS FURTHER GAINS IN U. S. SHIPBUILDING

From *Steel*, Feb. 12, 1940

Further substantial gains in American shipbuilding this year are predicted by J. Lewis Luckenbach, president, American Bureau of Shipping.

Marine engineering, he said in reviewing recent developments, continues to show marked improvement in fuel economy, with the trend toward high pressures and higher superheat increasing. Internal combustion engines are being installed in about one-third of the new maritime commission ships.

"Improvement," said Mr. Luckenbach, "is being made through the more general use of welding, and at least ten all-welded ships of the larger types may be expected to be delivered during the year, while increased welding will be typical for all."

Two hundred twenty-two vessels of 1,157,365 gross tons were being built to the bureau's classification Jan. 31st, according to Mr. Luckenbach, compared to 177 vessels of 677,980 gross tons a year ago. Ships now under construction include 20 large tankers; 105 vessels for the United States maritime commission; two cargo vessels for American Export Lines; three passenger-cargo vessels, Mississippi Shipping; three cargo ships, Seas Shipping Co.; two seatrain vessels, Seatrain Lines; and one large passenger ship, United States Lines.

While 28 vessels, 2000 gross tons or over, with a total gross tonnage of 239,958 were delivered in 1939, 52 seagoing ships with aggregate gross tonnage of 470,500 will probably be completed this year.

---

## GUIDE FOR WELDING 30 DIFFERENT METALS AND ALLOYS

A valuable guide to welding commonly used metals and alloys has recently been printed in chart form by The Linde Air Products Company, a Unit of Union Carbide and Carbon Corporation. Recommended welding method, flame adjustment, welding rod and flux for each of

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the 30 different metals and alloys can be determined at a glance by referring to this handy outline. Copies of this chart, Form 4464, can be obtained without cost by writing the nearest office of The Linde Air Products Company or the company's headquarters office, 30 East 42nd Street, New York.

## 1939 BOOK OF A. S. T. M. STANDARDS

Publication work on the 1939 Book of A. S. T. M. Standards has recently been completed and copies of this important publication are now available.

Important changes are incorporated in this latest A. S. T. M. publication. For the first time, it contains *all* of the Society's specifications, whether standard or tentative. Formerly the tentative specifications were issued in an annual volume, but the convenience of having these and the formally adopted standards in one volume led to the present combination. The Book is in three parts, instead of two parts as formerly, Part I covering Metals; Part II, Nonmetallic Materials—Constructional; Part III, Nonmetallic Materials—General—the divisions being as follows:

*Part I, Metals.*—Ferrous and non-ferrous metals, except methods of chemical analysis. General testing methods.

*Part II, Nonmetallic Materials—Constructional.*—Cementitious materials, concrete, masonry building units, ceramics, pipe, timber and preservatives, paints, road materials, waterproofing materials, soils, general testing methods.

*Part III, Nonmetallic Materials—General.*—Fuels, petroleum products, electrical insulating materials, rubber, textiles, soaps and detergents, paper, plastics, water, general testing methods, thermometers.

The Society continues the publication of its volume on Chemical Analysis of Metals including 19 methods covering 250 pages. This book is of interest to special groups and the material has not been included in the Book of Standards.

### Supplements

The method of issuing the 1939 Book of Standards also provides that a Supplement to *each* of the three Parts will be issued in 1940 and 1941. These volumes (estimated pages 350 to 500 each) will contain all new and revised standards and tentative standards, and revisions, approved in the respective years.

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| Supplements for 1940 and 1941: | | | |
| List Prices (Each Year) | 3.00 | 5.00 | 7.00 |

For half-leather binding add $1.00 for each Part and each Supplement.

## OBITUARY

### James Burke

James Burke, internationally known electrical engineer and inventor, who was president of the Edison Pioneers, formed of associates of Thomas A. Edison, died at his home at Erie, January 28th after a two-weeks' illness of pneumonia. His age was 66.

Born in Ireland, he was the son of the late James and Isabella Lynch Burke. He came to this country at the age of 18 and became an apprentice at the General Electric Company's plant in Schenectady, N. Y. After learning his trade he helped form the New York firm of Herrick & Burke, consulting engineers, and in 1898 went to Berlin to become technical director for the Bergmann-Elektricitaets Gesellschaft, a German-American company. He returned to America in 1903.

With George Winkler he founded the Burke Electric Company here. The firm later acquired control of the Keystone Electric Company. He served as president until 1928, when he was named chairman of the board. After retiring in 1930 he retained an advisory interest.

A pioneer in the industry, Mr. Burke had worked with Edison on various developments, often being called into consultation by him. A few years ago he was chosen by the Edison Pioneers to officiate at the dedication of the Menlo Park Memorial to Edison, where he turned on the constantly burning light.

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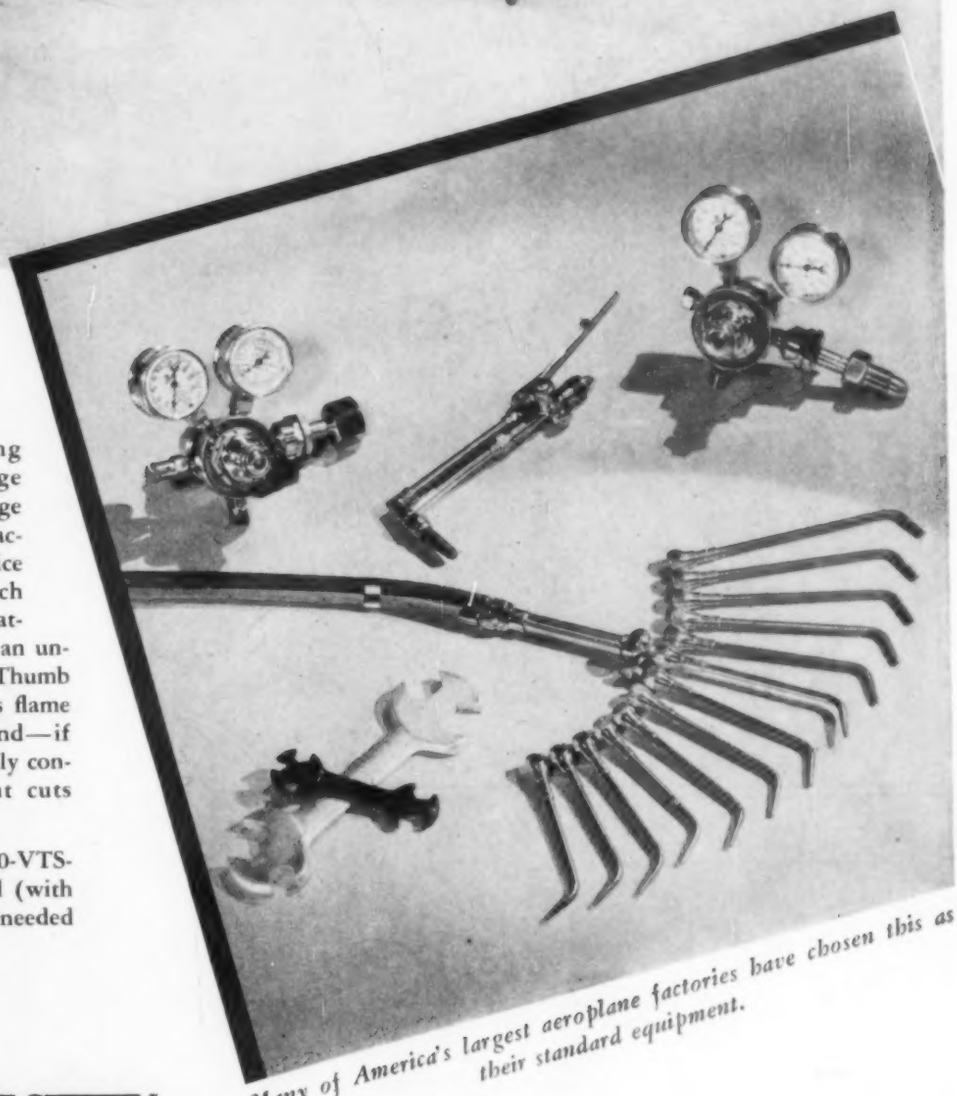

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Mr. Burke a few years ago presided at a session in Europe of the International Electro-Technical Commission, of which he was president. He was a former president of the National Electrical Manufacturing Association, a member of the American Institute of Electrical Engineers, the Society of Mechanical Engineers, the AMERICAN WELDING SOCIETY (founder member) and social and philanthropic organizations of Erie.

Mr. Burke was known chiefly for his invention of the three-wire generator, the universal motor and the "teaser" system for electrical printing-press control.

He leaves two brothers, Alfred Burke of New York and Stephen Burke of Montreal, and a sister, Miss Barbara Burke of New York. Another brother, John Burke, is dead. Mr. Burke's wife, the former Ann Gertrude Velder, died in 1928.

## AMERICAN CHAIN & CABLE COMPANY EXECUTIVES

C. N. Johns, a vice-president of American Chain & Cable Company, Inc., has been placed in charge of operations. Mr. Johns is a graduate of the University of Missouri. In 1913 he joined Page Steel and Wire Company, now a division of American Chain & Cable Company, Inc., as an employee in the operating department at the Monessen, Penna., Plant. After serving as assistant manager, he was made manager of the plant and then was appointed general manager of Page Steel and Wire Division, which post he has held for several years. As vice-president in charge of operations he will supervise the manufacturing activities of the company's 14 plants, in Connecticut, Pennsylvania, New Jersey, Michigan, Indiana, Texas and Canada.

George C. Moon, a vice-president of American Chain & Cable Company, Inc., has been appointed general manager of sales of the company. He became associated with American Chain & Cable Company, Inc., about 14 years ago when that concern took over the American Cable Company. He will continue active supervision of wire rope sales in connection with the wider responsibilities of his new duties. His headquarters will remain at 230 Park Avenue, New York Central Building, New York.

William D. Kirkpatrick, who has been general manager of sales of the American Chain Division, has been elected a vice-president of American Chain & Cable Company, Inc. Mr. Kirkpatrick has been with the company for more than 25 years. A graduate of Lafayette College, Class of 1910, he entered the employ of Weed Chain Tire Grip Company in 1914, as a salesman in the Philadelphia district. In 1934, he was transferred to Bridgeport, Conn., as sales manager of the automotive accessories division, and in 1936 he became general manager of sales of the American Chain Division, with headquarters at York, Penna. He will continue his headquarters at York, Penna., where he has supervision of the sales activities which are directed from that city, covering Weed Tire Chains, Welded and Weldless Chains, Manley Automotive Service Station Equipment, Wright Hoists and Malleable Castings.

## LOFTY COFFEE ROASTING PLANT RISING ON HUDSON

Structural steel for the 14-story coffee mixing tower which will dominate the Hills Bros. Coffee, Inc.'s new coffee roasting plant at Edgewater, N. J., will soon be rising across the Hudson River from Manhattan at 115th Street.

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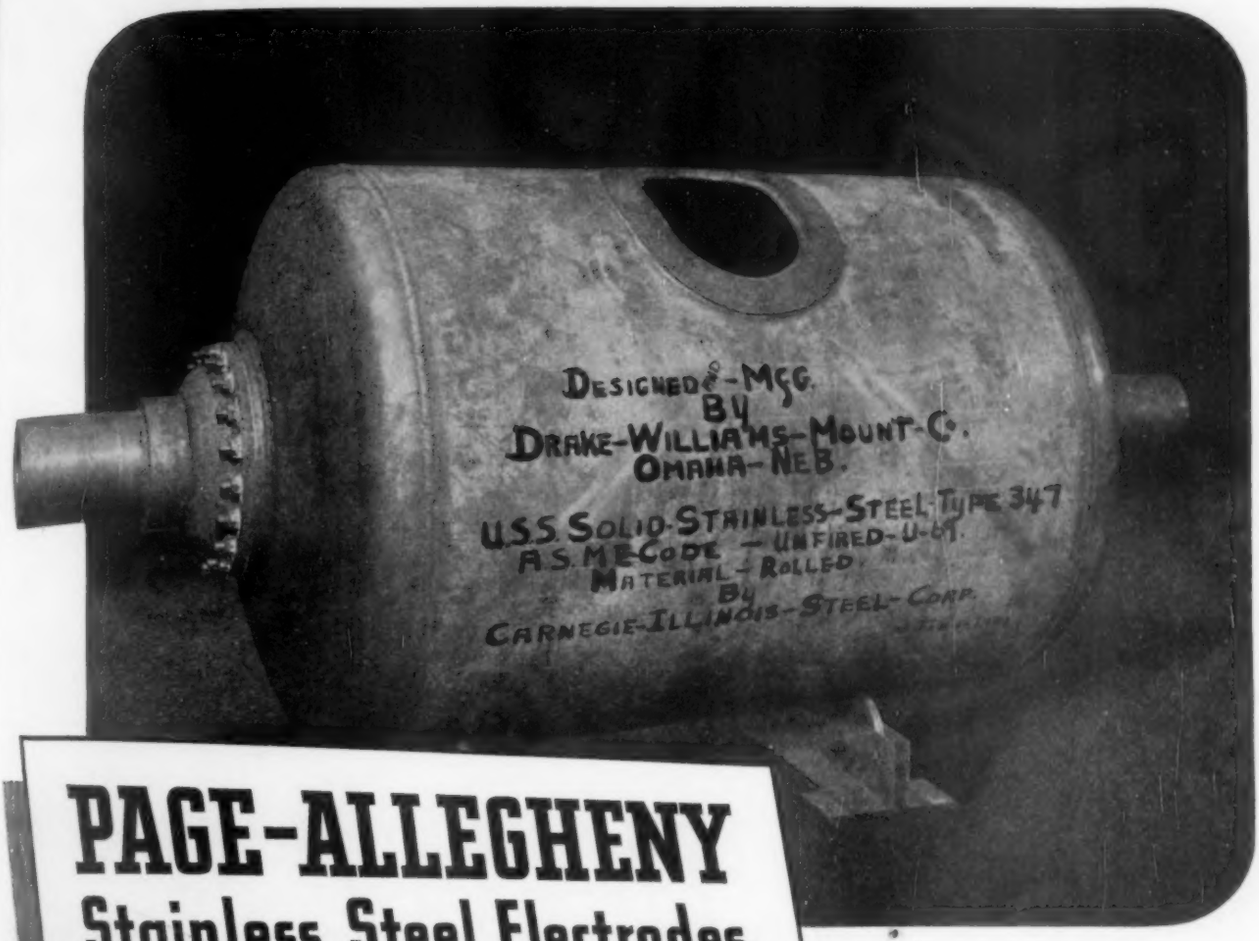


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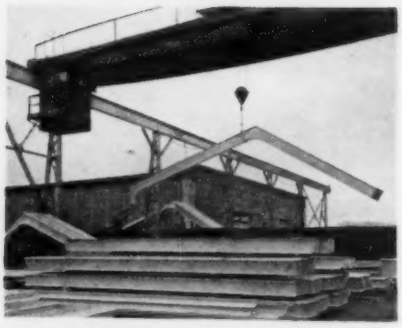

Fig. 1—Welded Roof Members for the 40-Foot Rigid Frame "Whaleback" Train Shed at Hills Bros. Coffee Inc.'s New 14 Story Plant Were Fabricated at the Cleveland Shops of The Austin Company

With structural steel for a train shed of unusual welded rigid frame design and the reinforced concrete skeleton for the six-story building which will surround the mixing tower already in place, motorists who travel up and down the Hendrick Hudson Parkway are beginning to recognize a new landmark across the river. The Austin Co. designed and is building the structure.

The 225,000 square foot plant will receive green coffee from the world's finest coffee plantations over a 620-foot conveyor shed, reaching out into the Hudson River and connecting the company's own pier shed to the plant. The plant proper has over-all dimensions 350 feet by 246 feet, although the mixing tower itself is only 75 feet square at the base. This will rise to a height of nearly 200 feet.

More than 700 feet of loading and unloading facilities for railroad shipments will be provided inside the train shed, where monitors admit light at the peak of gracefully arched aisles which introduce the special "whaleback" design developed by Austin engineers.

When completed the plant will include a dining room and recreation facilities for employees. All offices and employee quarters will be completely air conditioned as will be all processing sections in the plant where roasted coffee is handled in final packaging.

Fig. 2—More Than 700 Feet of Loading and Unloading Facilities Will Be Provided Inside This Unusual Train Shed at Hills Bros. Coffee, Inc.'s New 14 Story Plant at Edgewater, N. J.

The plant will be served by a boiler house which is already nearing completion. Newcomers to the East, Hills Bros. Coffee, Inc., are one of the largest importers and roasters of coffee on the Pacific Coast and in the central portion of the United States.

---

### ROEBLING SALES MANAGER

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*Photo by Bachrach*

Edward D. Emerson


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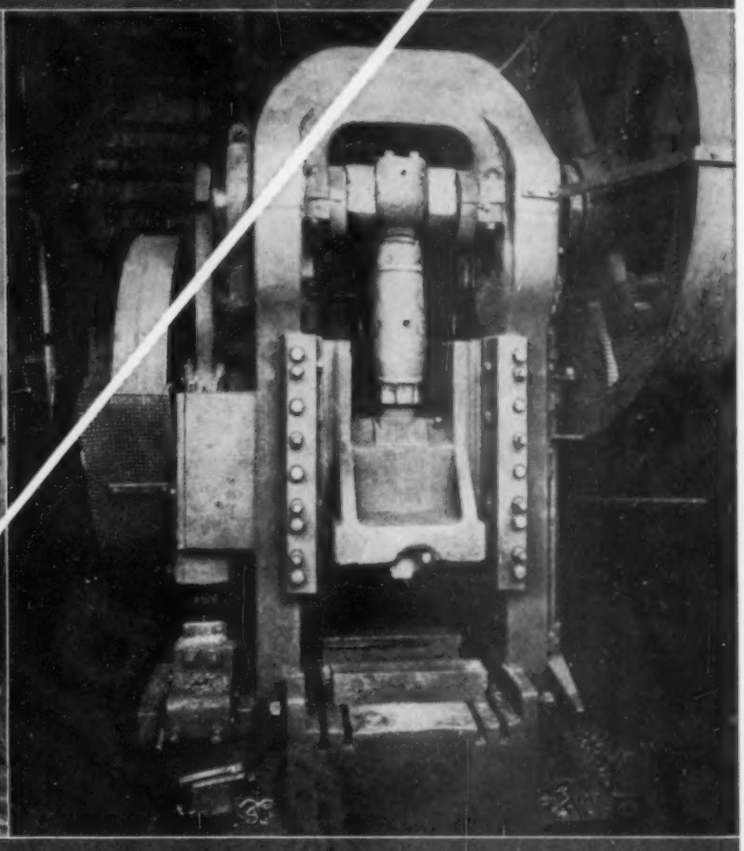


IN 46 HOURS!

# Thanks to Anaconda 997 Low Fuming Welding Rod

WHEN the Hebeler Welding Company of Buffalo, New York, were called in on this emergency job, they took one look at the fractured 4½-ton punch press; promptly recommended repair welding with Anaconda 997 Low Fuming Rod . . . a high strength, tough weld metal with low fuming characteristics.

The job consumed 160 pounds of filler rod and 1,600 feet of both oxygen and acetylene. Chipping, preheating with natural gas and compressed air and other preparation required 35 hours; welding, 11 hours. The result was a strong sound weld and a happy production manager, for the downtime loss was only a fraction of what he expected.

Next time you're faced with a similar emergency, bear this story in mind. Anaconda Rods are produced in an extensive line of alloys for all kinds of welding. You can obtain them from your jobber. 40119

ANACONDA from mine to consumer

Anaconda Welding Rods

THE AMERICAN BRASS COMPANY, General Offices: Waterbury, Connecticut

*In Canada: Anaconda American Brass Ltd., New Toronto, Ont. • Subsidiary of Anaconda Copper Mining Company*

been appointed General Manager of Sales for John A. Roebling's Sons Company, Trenton, N. J.

Mr. Emerson is a graduate in mechanical engineering, Harvard University, class of 1923. Previous to his employment with Babcock & Wilcox he was for several years sales engineer with the Jones & Laughlin Steel Corporation.

Mr. Emerson will assume his new duties on March 1st.

## SCULLY STOCK LIST

The 1940 Stock List and Reference Book of the Scully Steel Products Company, a subsidiary of the United States Steel Corporation is now available. It contains complete information as to lines, weights, list prices, etc., on approximately 11,500 items. This book, although published mainly for greater convenience in ordering material from stock, also contains a reference section which is valued quite highly by customers.

## RADIO CITY REMODELS SKATING RINK

In view of the interest aroused in the article we published on the above subject on page 60 of the January issue, we wish to advise that the photograph was furnished us through the courtesy of the Air Reduction Sales Company.

## WELDING DRYING TRAYS

There follows a shop view of a welder applying the arc in the welding of one of the 400 Monel drying trays. These trays are utilized by a nationally known dyestuff manufacturer in the drying of various dyes. These trays are fabricated from 20 ga. Monel sheet, electric welding construction throughout. Dimension 24 x 36 x $1^1/_2$ inches.

Fig. 1—Applying the Arc

Fig. 2—Helper Grinding Corner After Welding

## BOEING AIRCRAFT

Accompanying photographs, supplied by The Lincoln Electric Company, Cleveland, Ohio, show use of the modern shielded arc process of electric welding in construction of airplanes by the Boeing Aircraft Corp., Seattle, Washington.

Fig. 1

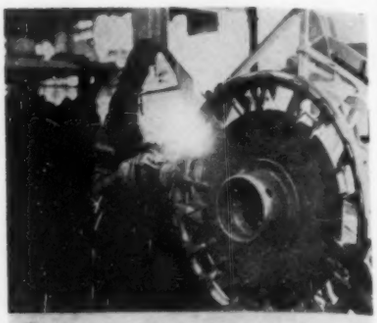
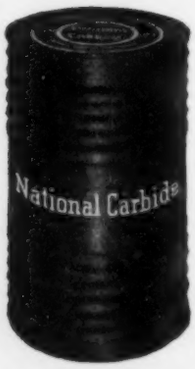


Fig. 2


National

Carbide




DEPENDABLE

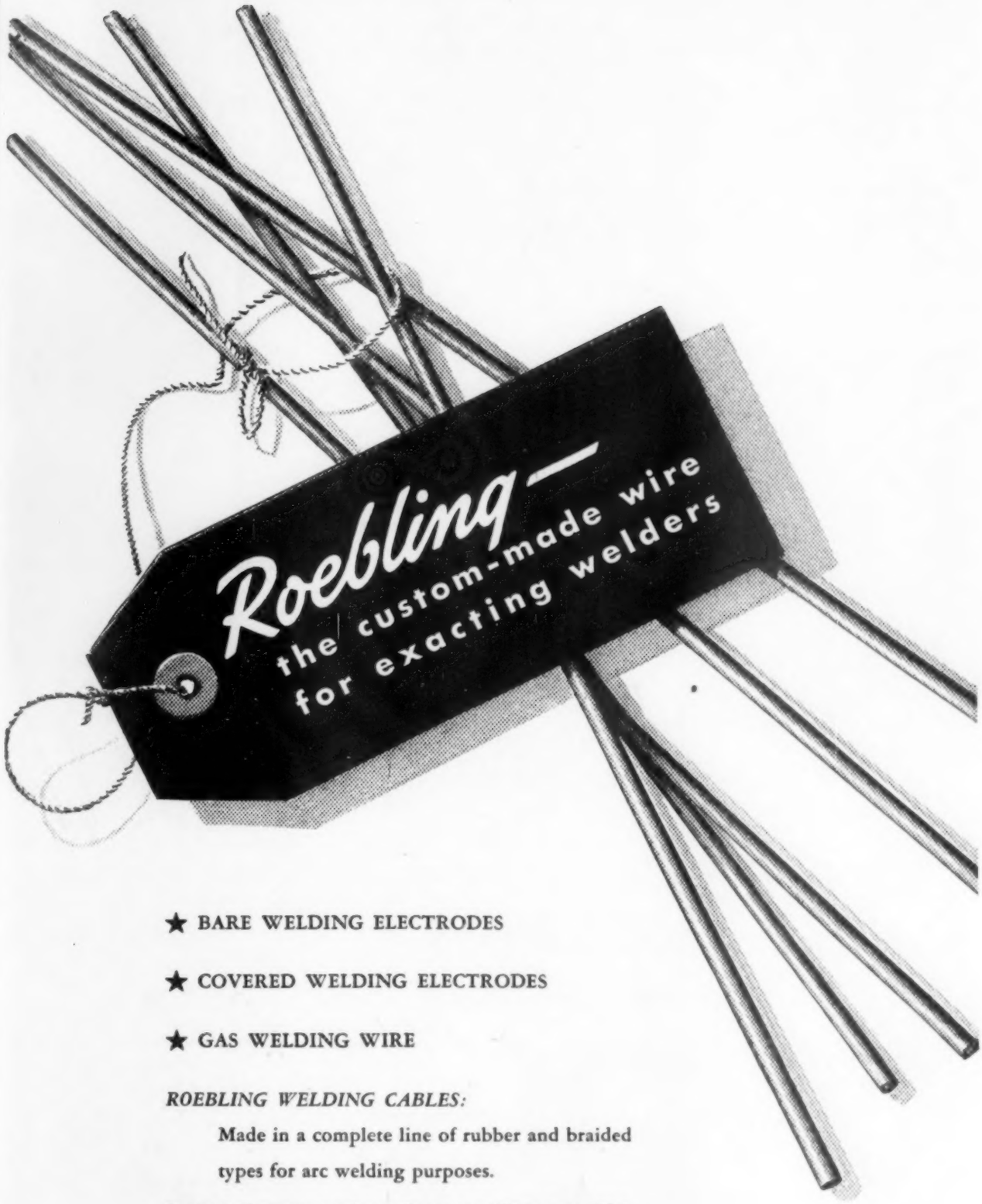
EFFICIENT

ECONOMICAL

FOR WELDING and CUTTING

Use National Carbide in the Red Drum

Lincoln Building — NATIONAL CARBIDE CORPORATION — New York, N. Y.




★ BARE WELDING ELECTRODES

★ COVERED WELDING ELECTRODES

★ GAS WELDING WIRE

*ROEBLING WELDING CABLES:*

Made in a complete line of rubber and braided types for arc welding purposes.

JOHN A. ROEBLING'S SONS COMPANY, TRENTON, N.J.
*Branches in Principal Cities*

**ONLY A FINE PRODUCT MAY JAR BEAR THE NAME ROEBLING**

In Fig. 1 arc welding is being used in construction of the engine mount of the "Stratoliner." Visible in the photo of the engine mount is a special jig which is also of arc-welded construction.

The illustration in Fig. 2 shows arc welding being used in construction of a special frame of tubular members which is used for picking up fuselages.

### IMPORTANT REPAIR JOB

When a large steel plant found that its sheet-mill roll frame was badly worn, it was repaired quickly by arc welding. The real problem was to get it done without stopping production of vital materials, so it was done during the Christmas period. The mill was shut down when Friday night's turn stopped and then dismantled, the 41,000-pound cast-steel housing being delivered to the machine shop of the Canadian Westinghouse Company at 10 A.M. on Saturday, December 23rd. Building up the surface to permit both the feet and bearing recess to be machined to the original contours and size required 405 cubic inches of weld metal weighing 115 pounds. This was obtained from 160 pounds of 1/4-inch downhand welding electrodes.

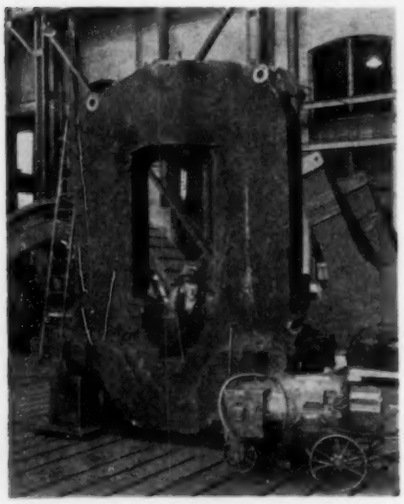


*Photo courtesy Westinghouse Elec. & Mfg. Co.*
**The Frame Set Up Ready for Welding, Showing the Massive Sections Involved**

# NEW PRODUCTS

**The Society assumes no responsibility for the validity of claims in this Section**

### TEMPILS

Tempils represent the newest technique in temperature control.

Tempil pellets have a sharp and rapid melting action at the stated temperature. Thus, Tempil 200 melts at 200° F., Tempil 300 melts at 300° F., etc. Tempils are accurate within 3% of the temperature which they are intended to indicate.

Tempil technique is simple. In application Tempils are merely placed upon or against the heated object. When the Tempil melts the heated object has reached the temperature stated on the Tempil.

Tempils are available in whole hundred degree ranges of 200°, 300°, 400° F., etc., and on request may also be had in 50 degree F. intervals.

Tempils are ideal for general shop use because of their simplicity. They have been successfully employed for the past two years for controlling preheating temperatures in hundreds of welding operations; for indicating temperatures in hot operations; and for checking thermocouples. The quality of work was found to be improved and rejections due to cracks were minimized.

Information may be obtained by writing to the manufacturer, Tempil Corporation, 132 West 22nd St., New York City.

### SHORT CIRCUITING GUN AND FIXTURE

Making spot welds in semi-inaccessible locations such as automobile reveal and garnish molding where intricately shaped, thin section welding points could not stand up under continued operation, is now being done with an unusual combination of short-circuiting gun and clamping fixture.

Fig. 1

The arrangement has more than tripled production speed over previous methods.

Fixture for either one or two man operation, designed and built by Progressive Welder Company, 737 Piquette Avenue, Detroit, Michigan, has an enclosed transformer short coupled to bus-bars which also serve as nesting dies for the work. A single hydraulically operated spot welding gun, of the short-circuiting type is used alternately by the two operators when production speeds require two man operation.

In operation, the window reveal "A" is first secured against the bus-bar die "B" (Fig. 2) by means of thumb clamps. The garnish molding is then placed in position over the nesting die which is so designed that when the hand clamp brings the molding under tension, the molding is forced securely against the reveal.


THOMSON

HEADQUARTERS FOR
Manual and Automatic SPOT, SEAM, BUTT, FLASH, PROJECTION, PORTABLE GUN, FABRIC and SPECIAL RESISTANCE WELDING PRODUCTION EQUIPMENT

*Write for FLASHES, a monthly magazine of Resistance Welding News and information. Sent free on request by*

THOMSON-GIBB ELECTRIC WELDING CO.
General Offices: 166 PLEASANT ST., LYNN, MASS.

FOOTE MINERAL CO.
1612 Summer St., Philadelphia, Penna.

LITHIUM
CHLORIDE-FLUORIDE
FOR
ALUMINUM WELDING FLUXES
COATED ALUMINUM ELECTRODES

*Thirty-five products for other types of Welding Fluxes and Electrodes*

## WHAT THE RESISTANCE WELDER MANUFACTURERS ASSOCIATION MEANS TO INDUSTRY

**STANDARDIZATION** permits selection of equipment on its merits without the confusion of numerous types.

**RESEARCH** stimulates new ideas, methods, and designs, thereby assuring continued improvement.

**PUBLICITY** of activities enables industry to keep abreast of latest developments.

**POLICY** to conduct our business, both individually and collectively on the highest standards of ethics.

**RESULT - - - - BETTER EQUIPMENT AT LOWER PRICE.**

## Resistance Welder Manufacturers' Association

505 Arch Street Philadelphia, Pa.

MEMBER COMPANIES

Acme Electric Welder Company, Los Angeles
American Electric Fusion Corporation, Chicago
Eisler Engineering Company, Newark, N. J.
Expert Welding Machine Company, Detroit
Federal Machine and Welder Company, Warren
Multi-Hydromatic Welding and Manufacturing Co., Detroit, Mich.
National Electric Welding Machines Co., Bay City
Progressive Welder Company, Detroit
Swift Electric Welder Company, Detroit
Taylor-Hall Welding Corporation, Worcester
Taylor-Winfield Corporation, Warren
Thomson-Gibb Electric Welding Co., Lynn
Welding Machines Mfg. Company, Detroit

ASSOCIATE MEMBER COMPANIES

P. R. Mallory and Co., Indianapolis
S-M-S Corporation, Detroit
Electroloy, Inc., New York
Welding Sales and Engineering Co., Detroit

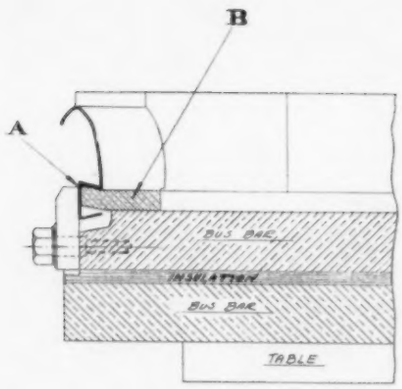


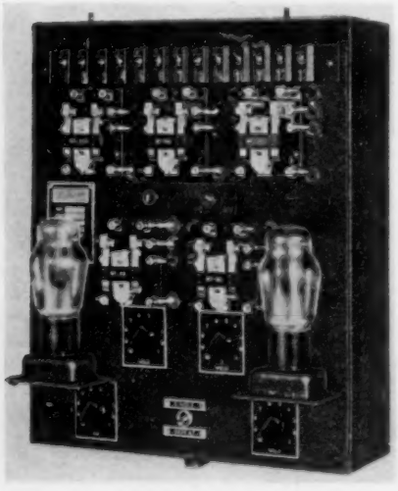

Fig. 2

The gun used is of the pincher type, pressure being supplied by an hydraulic pressure booster (not shown). To permit its admission in the concave side of the garnish molding only the tip of the upper electrode is of relatively thin section. Thus, ample cooling can be afforded to prolong electrode life. The lower electrode is of the button type contacting the bus-bar. Being suspended midway between the two operating stations, the welding gun is used by one operator while the other is placing and removing the work.

## NEW DUAL-TIME WELD TIMER

The "Dual-Time" timer, a single welding timer accurately controlling two spot welding guns at the same time through a single transformer, permitting four separate welding operations without changing the timer setting is announced by Weltronic Corporation, 2832 E. Grand Blvd., Detroit, Michigan.

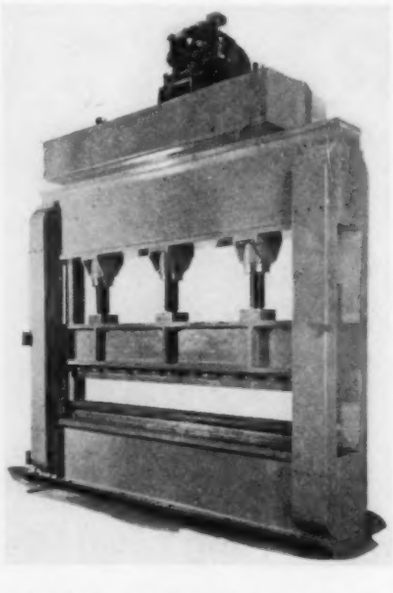
Of the electronic tube type, the new timer is provided with two separate time control dials for adjusting the weld time for each gun. Each gun being provided with two control buttons, the operator can, after the timer has once been set, make the proper time selection merely by pressing the proper button for the work to be welded. Thus, each gun may be used alternately as required for two different materials without further change.



## WELDED BULL PRESS

Contract Welders Inc. of Cleveland, Ohio have just announced a power driven unit known as a Bull Press. It is custom built to size and capacity of welded steel plate.

The press is suited for bending, forming, straightening and horning and was designed particularly for shops where there is a wide range of work requirement. An extension of ram and base provides horning space.



As illustrated the Bull Press has a capacity of 150 tons and is powered by a 25 hp. motor, a 2 speed reversing unit V belt connected to gearing which drives a set of buttress thread screws operating in bronze nuts to move the ram up or down.

## SPOT WELDERS

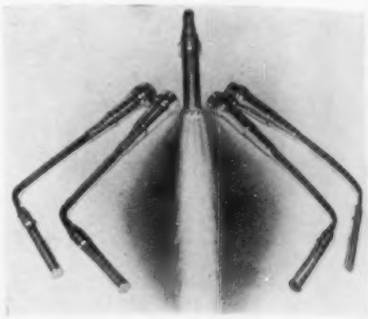
Catalog 40, describing and illustrating the complete line of Ace Spot Welders has just been published by the manufacturers, Pier Equipment Mfg. Co. of Benton Harbor, Michigan. In addition to the detail information on the various models, the newly designed contactor and the latest operating mechanism used on the 1940 manually-operated welders are fully explained. An interesting discussion on the choice of manual and automatic types is included. The catalog is for general distribution and is free to those interested.

## CUTTING BULLETIN

Combining the attention-commanding sweep of the broadside and the compact utility of letter-file dimensions when folded, Victor Equipment Company's new gas cutting-torch bulletin strikingly presents the constructive features of its hand- and machine-cutting torches. Color tin blocks heighten the display value of specimen numbers illustrating various models. Halftones of use on a wide variety of jobs are included.

## TIPS FOR HARD-SURFACING

This group of tips, designated as Rego GXH, series is available in four different sizes. They make it possible for any experienced operator to produce hard-surfacing jobs free of soft spots and pin holes.



Advantages claimed are:

1. Multiple-hole tip construction permits high heat output yet produces a soft, brush-like flame that eliminates turbulence in the weld puddle, thereby preventing detrimental pin holes in the applied hard-surfacing material after it has cooled.
2. The wide flame produced by the GXH tips makes it easier for the operator to keep the weld zone and the rod in a protective carbonizing flame envelope, thus eliminating harmful oxidation.

## STAINLESS STEEL ELECTRODE

A new stainless steel known as "Stainweld D" is announced by The Lincoln Electric Company, Cleveland, Ohio. "Stainweld D" should be used for arc welding stainless steel of the 25% chromium, 20% nickel type, such as Iron and Steel Institute No. 310.

"Stainweld D" is also used for welding various stainless steels to mild steel and for welding of steels which are air hardening and cannot be heat-treated after welding, such as both armor plate and similar steels.

Directions for its use are as follows.

Hold arc length short as possible without choking, or sticking.

Polarity: Electrode positive (+).

For best results use only enough current to obtain a free-flowing arc and proper fusion to base metal.

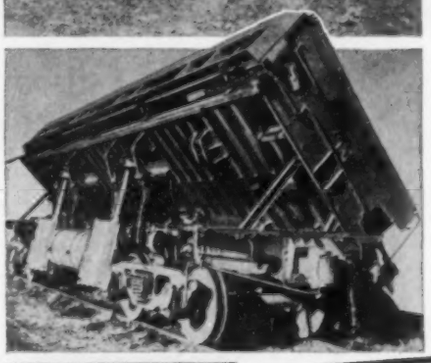
## SUPERHEATERS

"Elesco Superheaters" is the title of a 24-page catalog just issued by Combustion Engineering Company, Inc., 200 Madison Avenue, New York. Details of construction of both the ball-joint and the welded types are covered and numerous diagrams show various arrangements for application to different types of boilers and to meet different conditions. Control of superheat by means of by-pass dampers is explained. The catalog is confined to stationary practice for a wide range in pressures and temperatures.

# MINING PAYS *Bigger Dividends*

## — thanks to *welded* equipment, built lighter from stronger, longer-wearing **ROLLED STEELS**

**Giant coal stripping shovel,** built by the Marion Steam Shovel Company, increases dipper capacity from 18 to 23 cu. yds., with no reduction in dipper strength, by replacing the heavy cast dipper with one built of U·S·S MAN-TEN Steel.



**A 20% saving in weight**—greater strength—obtained by using U·S·S MAN-TEN and welded construction to fabricate these rotary ore dump cars. And MAN-TEN's ability to resist abrasion—to stand up under gruelling treatment—will make them wear longer.

**6 Cars Weigh Less Than 5**—Arc-welded, low alloy steel used throughout in the construction of this 30 cu. yd. railroad dump car was responsible for a reduction in weight from 69,000 pounds to 57,000 pounds.

COAL and ore move faster and at lower cost in welded, rolled steel equipment. And it's easy to see why!

Because it puts steels with special properties to work in strategic places, rolled steel construction, replacing other types of fabrication, has increased capacity without increasing weight, given greater strength with no addition of profit-eating poundage, made parts subject to severe abrasion wear longer. One company, for example, used rolled steel welded construction in a dipper bucket's swivel guide — and saved 5000 pounds of deadweight. Another saved 20% on mine car weight. Still another increased the handling capacity of its refuse buckets by approximately 40%.

Results like these a few years ago might have seemed impossible. Today they are commonplace throughout industry. Welded rolled steel construction has come into its own! We'll be glad to show you how it can improve your product or your machinery.

***For lighter, stronger, longer-wearing mining equipment fabricate it by welding with these better steels:***

**U·S·S Cor-Ten**—to resist corrosion, to reduce weight or increase strength.

**U·S·S Man-Ten**—to increase strength without adding weight.

**U·S·S Abrasion Resisting Steel**—for use where abrasive conditions are exceptionally severe.

**U·S·S Heat Resisting Steel**—to combat high temperatures.

**U·S·S Stainless Steel**—to resist corrosion of all kinds.

**U·S·S Carilloy Alloy Steels**—to carry tremendous bearing pressures.

CARNEGIE-ILLINOIS STEEL CORPORATION, *Pittsburgh and Chicago*
COLUMBIA STEEL COMPANY, *San Francisco*
TENNESSEE COAL, IRON & RAILROAD COMPANY, *Birmingham*
United States Steel Export Company, New York

# UNITED STATES STEEL

### WELDING COURSE

The Welding Division of the Industrial Engineering Department, The Ohio State University, Columbus, has found that there is need to provide practicing engineers with an opportunity to obtain basic information in some of the fundamentals which now form the basic sciences for the four-year welding course.

Accordingly, there is being established a Special Short Course (of three days' duration) in Welding Engineering. This course will be given in place of the Annual Welding Engineering Conference which has been held on the campus each year since 1931. Lectures will be given by prominent engineers in the welding field as well as by members of the University staff.

This year the dates have been tentatively set for April 16th, 17th and 18th. There are to be three classes daily for the three days with several of the classes devoted to the same subject covering it progressively. A nominal registration fee will be charged, which will be held to a maximum of $5.00.

Information can be obtained by writing J. R. Stitt, Assistant Professor Welding Engineering, The Ohio State University, Columbus.

### NORTHERN NEW JERSEY—NEW SECTION

An organization meeting to form the Northern New Jersey Section of the AMERICAN WELDING SOCIETY will be held on March 14th at 7:30 P.M. in the auditorium of the Public Service Terminal Building, Park Place, Newark, N. J. Some interesting speakers have been secured for the occasion. Everyone invited.

Business will include the election of officers and a general talk on the work of the AMERICAN WELDING SOCIETY.

# » » » SECTION ACTIVITIES « « «

### CLEVELAND

The regular monthly meeting of the Cleveland Section was held on February 14th at the Cleveland Club. Dinner preceded the meeting. Mr. Geo. F. Wolfe, Chairman, Welding Committee, Engineering Works Division, Dravo Corporation, addressed the meeting on the subject, "Assembly Plant for the Mass Production of Barges and Other Structures."

A course of six lectures on "Welding Design" will be given by the Cleveland Section in April by Mr. O. N. Stone of Wellman Engineering Co.

### COLUMBUS

Mr. T. M. Jasper of the A. O. Smith Corporation was the speaker at the February 9th meeting of the Columbus Section. Mr. Jasper's subject was "Boiler and Insurance Standards for Welding."

### DETROIT

The subject, "Welded Piping—Codes and Practices," was presented by Mr. D. H. Corey, Welding Engineer, The Detroit Edison Company, at the February 9th meeting of the Detroit Section held at the Detroit-Leland Hotel.

### GEORGIA

Mr. T. H. Gardner, Structural Engineer for the Florida East Coast Railway Company, gave the Georgia Section an informal talk and movies of the Bascule Bridges built for and on the Florida East Coast Railway, at the January meeting held on the 5th at the Piedmont Hotel, Atlanta. Mr. Gardner used slides during his discussion to show and illustrate how the Bascule Bridges were built.

### LOS ANGELES

The Los Angeles Section abandoned their regular meeting for December and in its place accepted an invitation from the American Society for Metals to meet in joint session. This meeting was held on December 19th at Schully's Cafe, Los Angeles.

The only speaker of the evening was Dr. V. N. Krivobok, Professor of Metallurgy of the Carnegie Institute of Technology, who held the undivided attention of the audience on the subject, "A Survey of Modern Stainless Alloys, Their Properties, Applications and Record." There were 263 members and guests present.

The regular monthly meeting of the Los Angeles Section was held on November 16th. There were seventy-six members and guests present.

The first speaker of the evening was Mr. W. J. Chaffee, Territorial Manager of Hobart Bros. Co., who presented a series of pictures of "Edgehill," a housing development made possible by Arc Welding. The pictures were very interesting, showing the complete fabrication of houses in a factory and moved intact to the tract, ready for occupancy.

The second speaker was Mr. Harold Wickstrom, Consulting Engineer, who gave a worth while talk on "Liquefied Petroleum Gases in Industry," describing their manufacture and various uses.

Mr. Roy Hansen, Los Angeles manufacturer of Butane Tanks & Equipment, told of the manufacture and fabrication of the tanks and sections showing their construction.

### LOUISIANA

A very interesting lecture on the Fundamentals of Welding and the Welding of Alloy Steels, by Mr. E. W. P. Smith, Consulting Engineer for The Lincoln Electric Company, was given at the January 31st meeting of the Louisiana Section.

The March meeting of the Louisiana Section will probably be held on the 22nd.

### MARYLAND

The Maryland Section were honored by having Mr. H. C. Boardman of the Chicago Bridge and Iron Company and former President of the SOCIETY, lecture at their meeting on February 16th held at the Engineers' Club, Baltimore.

At the March 15th meeting, Mr. Basil Osmin of the Maryland Casualty Co. will furnish a speaker who will talk on the welding of high-pressure pipe.

At the January 19th meeting, Mr. Robert C. Fitzgeral, Welding Engineer of the Consolidated Gas & Electric Co., Westport Station, talked on Procedure of Welding. His lecture was most interesting.

The following is a poem dedicated to a welding torch which Mr. Roy A. Mansfield, Secretary of the Maryland Section, says may help some welder on a blue Monday.

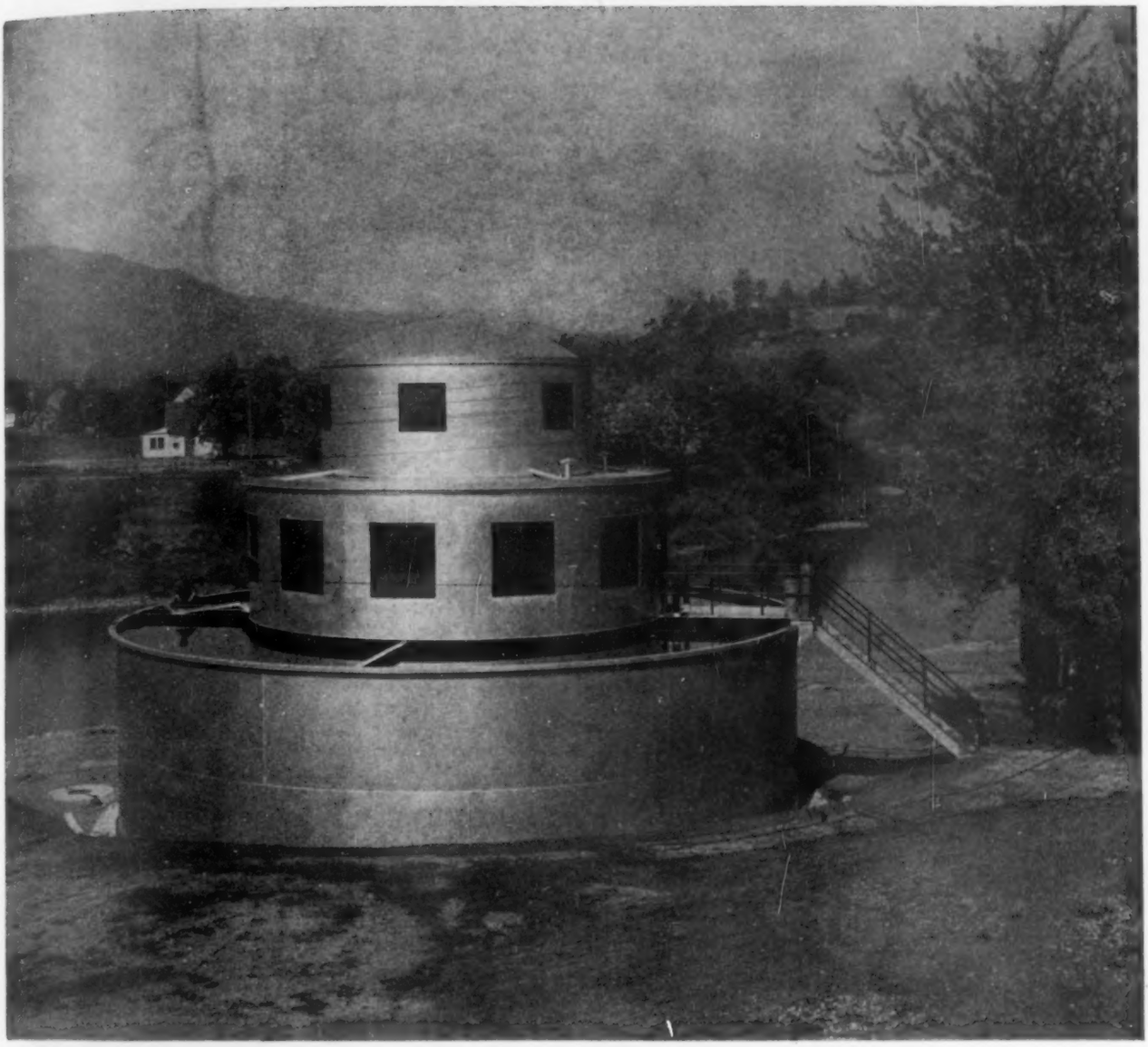
**The Prayer of a Welding Torch**

By Roy A. Mansfield

I pray, O God, you will vest in my
creator the power and design to free my
user's mind!
I've been designed by an engineer;
To him I am a pride most dear.
He designed in me the power to please
The welder, who now works with ease.
I hold a flame so mild and hot—
To fuse metals is my lot.
If I should spit or pop or flare,
Don't throw me down; and please don't
swear.
Just shut me off and investigate;
'Tis dirt in the line, so do not wait.
Clean me out and treat me kindly,
There is no need to go on blindly.
I'll do the things you want me to
If you remember what I'm designed to
do.
The work will be better, I think you'll find,
And that will be sure to ease your mind.

### MILWAUKEE

A National President's Night was held by the Milwaukee Section on January 26th. Mr. George T. Horton, President of the AMERICAN WELDING SOCIETY and President of the Chicago Bridge & Iron Co., was the guest of the evening. Mr. Horton, the inventor of the Hortonsphere and a pioneer in the development of special



# MORSE FILTER PLANT

## . . . . . of welded construction

The 720,000-g.p.d. Morse filter plant illustrated above at New Bethlehem, Pa., is of welded steel construction. The piping connections, valves, sight well, etc., are located in a circular pipe vault at the center. The operating floor—directly above the pipe vault—and the filters in a concentric ring around it, are enclosed. The mixing units and coagulating basins occupy the outside ring and are not covered. ¶ Morse filter plants are compact. All parts are accessible for inspection and painting. Loss of head through them is low. The steel walls are impervious, preventing seepage. They will not crack due to uneven settlement or develop leaks at the joints.

## CHICAGO BRIDGE & IRON COMPANY

| | | | | | |
|---|---|---|---|---|---|
| Chicago | 2455 Old Colony Bldg. | Birmingham | 1507 North 50th Street | Philadelphia | 1668-1700 Walnut St. Bldg. |
| New York | 3398-165 Broadway Bldg. | Tulsa | 1654 Hunt Bldg. | Boston | 1565 Consolidated Gas Bldg. |
| Cleveland | 2282 Rockefeller Bldg. | Houston | 2919 Main Street | San Francisco | 1097 Rialto Bldg. |
| Dallas | 1489 Liberty Bank Bldg. | Detroit | 1556 Lafayette Bldg. | Los Angeles | 1455 Wm. Fox Bldg. |

*Fabricating plants in CHICAGO, BIRMINGHAM, and GREENVILLE, PA.*

designed storage tanks for gases and liquids, spoke on "Illustrations of Special Welded Plate Structures." Mr. Horton's talk was illustrated with slides.

## NEW YORK

The New York Section held a meeting on Tuesday, February 13, 1940, at 7:30 P.M. in Room 502, Engineering Societies Building, 33 West 39th Street, New York, N. Y. The Chairman was Mr. J. T. Phillips, Superintendent of Boiler Shop, Foster Wheeler Corporation, Carteret, New Jersey Works, and First Vice-Chairman, New York Section, A. W. S. The speaker was Mr. John J. Crowe, Manager, Apparatus Research & Development Department, Air Reduction Sales Company. Mr. Crowe's subject was "Heat Treatment with the Oxyacetylene Flame." The lecture covered the chemical and metallurgical effects of flame cutting and machining on steels of various compositions, and the use of the oxyacetylene torch for the hardening and softening of steels. A number of interesting lantern slides were shown. Following the paper, an interesting technicolor motion picture entitled, "The Flame Hardening Process," which illustrated flame hardening of gear and sprocket teeth and lathe way surfaces was presented. The attendance was approximately 160. Both the lecture and the motion picture were very well received and an interesting discussion was held afterward.

## NORTHWEST

This Section has held during the past three months some unusually interesting and valuable meetings.

December 12, 1939, Mr. R. F. Flood, Process Service Engineer, The Linde Air Products Company, discussed "Oxyacetylene Cutting and Flame Hardening," illustrated by lantern slides and also showed the company's film, "Unionmelt Welding."

January 16, 1940, Mr. F. G. Flocke of the International Nickel Company, discussed "Fabrication of Monel, Nickel and Inconel in Solid and Clad Plate Constructions."

February 13, 1940, Mr. H. T. Pott, President of the St. Louis Shipbuilding and Steel Company, spoke on "Arc Welding as Applied to Steel Hulls."

The Section feels very much indebted to these gentlemen for their valuable contributions, which were of so much benefit to the members and guests.

## OKLAHOMA CITY

The regular monthly meeting of the Oklahoma City Section was held in the Biltmore Hotel, Friday evening, February 2nd. This was a dinner meeting. Attendance prizes were awarded as usual for the dinner meeting, one prize going to Mr. Bennie Schultz of Norman and another to Mr. J. L. Lang of Oklahoma City. Preceding the main address a motion picture on "Sulphur" was shown. This picture, made in cooperation with the Texas Gulf Sulphur Company, showed the mining of sulphur in Texas and the various uses of sulphur in the industries of this country.

The address, "Metal Spray for the Protection of Refinery Equipment," was given in the form of a paper by Mr. E. K. Dewey of the Continental Oil Company. Mr. D. R. Johnson, also of the Continental Oil Company, assisted in the discussion and answering of questions regarding the metallizing process at refineries.

There was a great deal of interest shown in this subject as evidenced by the number of questions and discussions which followed the address. There were eighteen present at the dinner and thirty-nine members and guests for the meeting.

## PHILADELPHIA

Mr. I. T. Hook of The American Brass Company, addressed the February 19th meeting of the Philadelphia Section, on the subject "Welding of Copper Base Alloys."

The March meeting will be held as usual in the Engineers' Club, on the 18th at 8 P.M. Fabrication of Pressure Vessels by Welding will be presented by the M. W. Kellogg Company.

The April meeting will be held on the 15th. Welding in Marine Industry will be presented by the American Bureau of Shipping.

It is planned to have an inspection trip on May 20th to one of the very large manufacturing plants.

## PITTSBURGH

Mr. W. B. Nicholson, Engineer for The Linde Air Products Company, spoke on the subject, "Flame Hardening and Its Applications," at the February 21st meeting held in the Mellon Institute of Industrial Research.

Plans are under way for the Tri-State Welding Conference to be held April 26th jointly with the Engineers Society of Western Pennsylvania in the William Penn Hotel, Pittsburgh.

The next regular meeting of the Pittsburgh Section will be held Wednesday night, March 20th, in the Mellon Institute of Industrial Research at which time Mr. L. C. Bibber, Welding Engineer, Carnegie-Illinois Steel Corporation, will speak on the subject, "Experimental Background to Welded Design."

## PUGET SOUND

Two meetings were held during February by the Puget Sound Section in order to take advantage of the visit of two national figures in the welding industry.

On Monday evening, February 5th, the regular dinner meeting was held at the Engineers' Club with 65 members and their guests attending the dinner and ten additional members and guests attending the lecture. Mr. J. F. Lincoln, President, Lincoln Electric Company, Cleveland, Ohio, gave an illustrated lecture on Arc Welding. His talk was very well received and enjoyed by those present and a general forum was held at the meeting which brought out a lot of intelligent discussion.

On Monday evening, February 12th, a similar dinner meeting was held, attended by 70 members and guests. Mr. Leon C. Bibber, Welding Engineer, Carnegie-Illinois Steel Corporation, spoke on the problem of locked stresses and distortion in welding design. As usual, an open forum was held after the meeting.

## ROCHESTER

The Rochester Chapter heard Mr. A. N. Kugler, Engineer with the Air Reduction Sales Co., at their Jan. 5th meeting. Mr. Kugler's chalk talk on the "A-B-C's of Oxyacetylene Welding" and colored film on "Welding of Red Brass Pipe" made the meeting very interesting.

Those attending the dinner prior to the monthly business meetings are promised not only good food but interesting Coffee Talkers. These men are not announced and speak on topics of interest not necessarily welding.

At the February 7th meeting Mr. R. D. Thomas of the Arcos Corporation, Philadelphia, gave a very complete paper on "Stainless Weld Metal and the Welding of Stainless Steel."

## ST. LOUIS

The first meeting of the new year saw double the attendance who were awarded by an enlightening talk on the A. W. S. Standard Qualification Tests by Mr. H. C. Boardman, former President of the Society.

The St. Louis Section is very enthusiastic about their educational course in "Welding Metallurgy" that started on February 6th and is to continue on ten successive Tuesday nights in the auditorium of the Laclede Gas Light Company,[1] 1017 Olive Street, from 7:30 to 9:30 P.M. Scheduled speakers include F. X. Hohn, Metallurgist, Scullin Steel Company; M. E. Meyerson, President, St. Louis Testing Laboratory, Inc.; M. B. Sciotetich, Metallurgist, Combustion Engineering Company; and F. C. Fantz, Vice-President, Midwest Piping & Supply Co.

One hundred and fifty members and guests turned out to welcome the District Vice-President, A. J. Moses, at the February 9th meeting. His excellent paper on the welding of stainless steels for pressure vessels included the selection of material problems, fabrication difficulties and application uncertainties.

## SAN FRANCISCO

A joint meeting with the American Society for Metals was held on January 23rd. The first speaker of the evening was Dr. Baldwin M. Woods, Professor, Department of Mechanical Engineering, University of California. His subject was on "Power in the Metal Industries of California." Following Dr. Woods' talk, Mr. M. Judkins, Chief Engineer of the Firth-Sterling Company, Carbide Division,

[1] Because of an extra large attendance at the first course it has been necessary to move the course to the Bryan Mullanphy School, 4225 Shaw Ave., St. Louis.

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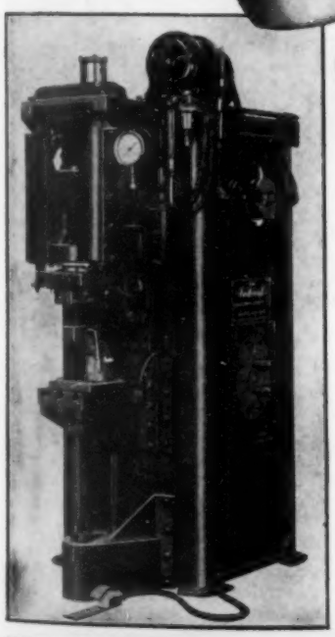

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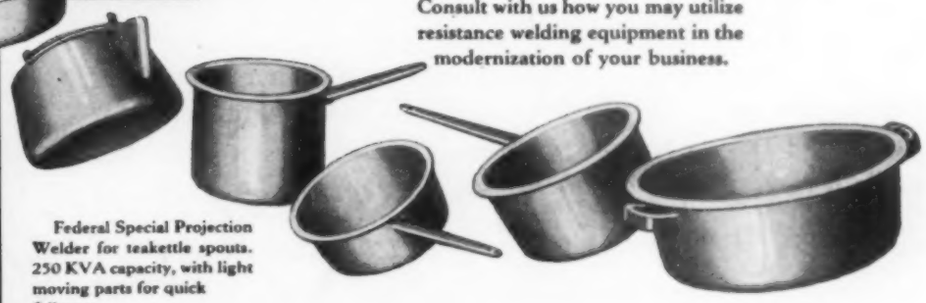

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IN ENGLAND, MADE BY BRITISH FEDERAL WELDER & MACHINE CO. LTD., DUDLEY, ENGLAND

spoke on "New Developments in Carbide Cutting Tools."

Mr. Leon C. Bibber of the Carnegie-Illinois Steel Corporation was the guest speaker at the February 9th meeting. He spoke on "The Experimental Background to Welding Design," which was illustrated with slides.

### SOUTH TEXAS

The regular monthly meeting of the South Texas Section was held on January 12th. Mr. F. C. Hutchison of The Linde Air Products Company gave a very interesting and educational talk on the subject, "Unionmelt." This created considerable interest and many questions were asked by members in the audience.

The February meeting was held on the evening of the 16th. Mr. W. E. Klauberg, Laboratory Technician of Wyatt Metal & Boiler Works, Houston, spoke on "Welding of Pressure Vessels as Seen through the X-ray."

### WESTERN NEW YORK

Due to his being transferred to New York City, Mr. Frank Howard tendered his resignation as treasurer of the Western New York Section. Mr. Robert Siemer of Allan Welding Company, Buffalo, was elected treasurer to take over Mr. Howard's duties. Mr. Randall Schleich, Travellers Indemnity Company, Buffalo, was made the new chairman of the Membership Committee.

At the January 18th meeting Mr. Charles H. Jennings, Research Engineer in Charge of Welding, Westinghouse Electric & Manufacturing Company, presented an address on "Distortion Problems in Welding." Mr. Jennings gave a very interesting presentation of some of the problems connected with distortion in welding and how to solve them.

In spite of the fact that there was a terrific blizzard blowing on this particular night, there was an attendance of approximately seventy.

### WICHITA

Mr. O. Trentham, Process Service Supervisor, Rocky Mountain Area, The Linde Air Products Company, Denver, Colo., was the main speaker at the February 9th meeting. His subject was "A Practical Discussion of Welders' Problems." Mr. Trentham preceded his talk by showing a number of natural color slides which have been taken in his travels in and around the Rocky Mountain area. These slides showed very vividly the wonderful scenery that can be seen in this area and was very well received by the group of about sixty members and guests.

### YORK-CENTRAL PA.

The fourth monthly meeting of the York-Central Pa. Section was held on January 15th at which time the Section was addressed by Mr. A. E. Gibson, President of the Wellman Engineering Company. Attendance at this meeting was about 95 and it was a very interested group who heard Mr. Gibson speak on "Elements Affecting the Cost of Welded Products."

The February meeting will be held on the 21st, at which time the speaker will be Mr. W. D. Halsey, Assistant Chief Engineer of the Boiler Division of the Hartford Steam Boiler Inspection and Insurance Company, who will speak on the A. W. S. Standard Qualification Procedure. Mr. Halsey is Chairman of the Committee on this subject. His address will cover a general discussion of the need for a definite welding procedure and how the various factors are evaluated. He will also emphasize the necessity for properly qualifying welding operators and the best method for determining their ability to make good welds.

The March meeting will be a dinner meeting and will be addressed by Mr. J. F. Lincoln, President of The Lincoln Electric Company, whose subject will be "Welding versus Prejudice."

# List of New Members

**January 1st to January 31, 1940**

### BOSTON

**Braithwaite, Alexander** (C), 1 Weelahka Place, Worcester, Mass.
**Jarvis, Allen J.** (D), 114 Birch St., Roslindale, Mass.
**McNall, Richard C.** (D), Still River, Mass.
**Norton, Peter J.** (C), 7 Forest Circle, Winchester, Mass.
**Roberts, Arthur W.** (D), 1117 Tremont St., Boston, Mass.
**Sher, Barney** (C), 566 Beach St., Revere, Mass.

### CANADA

**Kelly, J. J.** (B), Lincoln Elec. Co. of Canada, Ltd., Haymarket Square, Hamilton, Ont., Canada.
**Roast, Harold J.** (B), Canadian Bronze Co. Ltd., 999 Delorimier Ave., Montreal, P. Q., Canada.
**Walker, Walter Francis** (C), Herbert Morris Crane & Hoist Co., P. O. Box 180, Niagara Falls, Canada.

### CHICAGO

**Goodwin, Harris A.** (B), The Bastian-Blessing Co., 240 E. Ontario St., Chicago, Ill.
**Johnson, N. E.** (B), The Bastian-Blessing Co., 240 E. Ontario St., Chicago, Ill.
**Owen, J. C.** (B), The Bastian-Blessing Co., 240 E. Ontario St., Chicago, Ill.
**Paschke, Paul** (D), 2700 Fletcher St., Chicago, Ill.
**Stiff, Lawrence E.** (D), 1709 Prairie Ave., Chicago, Ill.
**Wigton, M. H.** (B), 839 Sheridan Rd., Chicago, Ill.
**Wilson, T. F.** (B), The Bastian-Blessing Co., 240 E. Ontario St., Chicago, Ill.

### CINCINNATI

**Heckmann, A. A.** (F), 3654 Middleton Ave., Cincinnati, Ohio.

### CLEVELAND

**Hinger, Roy E.** (C), 8995 Ann Court, Cleveland, Ohio.
**Malloy, Paul V.** (B), 1562 Marlowe, Lakewood, Ohio.

### COLUMBUS

**Beyer, Edwin R.** (F), 172 West Lane Ave., Columbus, Ohio.
**De Larzelere, F. P.** (B), 780 Euclair, Columbus, Ohio.

### COLORADO

**Roggow, H. A.** (C), Heeney, Colo.

### CONNECTICUT

**Babin, John** (C), Chase Brass & Copper Co., Waterbury, Conn.
**Jones, Glen W.** (D), 321 Bridgeport Ave., Devon, Conn.
**Schneider, Edward A.** (C), General Elec. Co., Bridgeport, Conn.
**Taylor, Richard H.** (A), Electroloy Co., Inc., 1600 Seaview Ave., Bridgeport, Conn.

### DETROIT

**Raab, Carl** (C), 19218 Spencer St., Detroit, Mich.
**Scotten, Frank M.** (B), Great Lakes Engrg. Wks., River Rouge, Mich.

### GEORGIA

**Hawkins, S. R., Jr.** (C), Page Steel & Wire Div. of American Chain & Cable Co., 1011 Healy Bldg., Atlanta, Ga.

### HAWAII

**MacQueen, Richard W.** (D), Box 88, Makaweli, Kauai, T. H.

### INDIANA

**Grubbs, Paul F.** (C), P. R. Mallory Co., 3029 E. Washington St., Indianapolis, Ind.

### LOS ANGELES

**Bertelsen, Linn** (D), 510 N. Poinsettia St., Compton, Calif.

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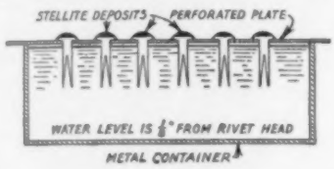
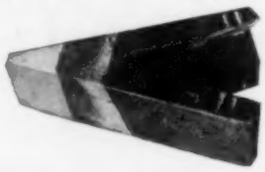
BELT RIVETS—A quick and economical way to prolong the service life of belt rivets in abrasive service such as exists in cement mills is illustrated by the accompanying




sketch. Only a drop of Haynes Stellite hard-facing rod is needed on each rivet head. No preliminary grinding of the heads or subsequent heat-treatment is required.

DIPPER TEETH — Hard-facing economies are most noticeable when wearing parts used in quantity are reclaimed. For example, a set of 900-lb. dipper teeth for a stripping shovel outlasted 6 regular sets when hard-faced with Haynes Stellite



alloy. One of the teeth is shown above. When they finally wore down, the edges were squared up with chrome-molybdenum welding rod and resurfaced with Haynes Stellite rod.

Write for the 104-page book, "Hard-Facing With Haynes Stellite Products," which gives over 500 examples of hard-facing economies being obtained in various industries.

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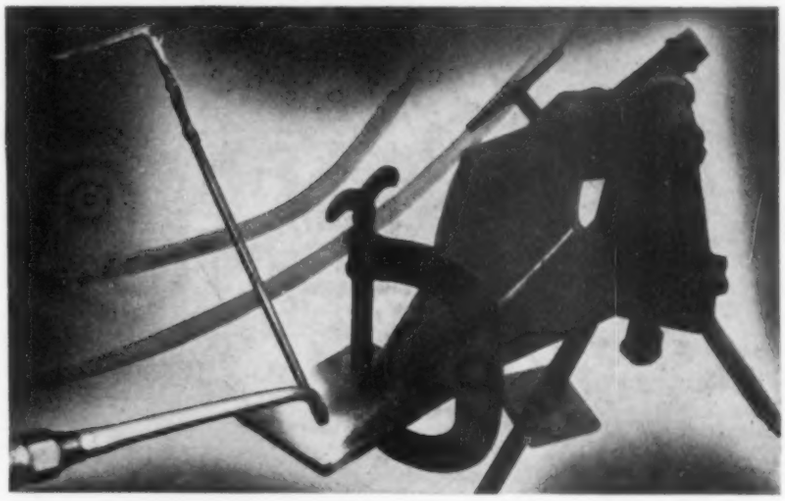
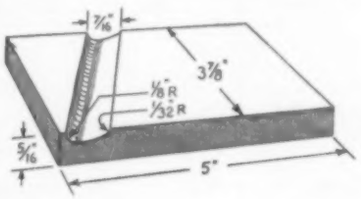


## Helps for Hard-Facing Plowshares

The use of a nose plate and simple jig aids in applying Haynes Stellite hard-facing rod to the nose and cutting edge of plowshares. The sketch at the right gives the dimensions of the copper nose plate, being used above for molding the Haynes Stellite rod to proper shape on the nose of the share. Jigs for holding the share at the desired angle can be easily and inexpensively made.




Steel shares are hard-faced on the nose and cutting edge; cast iron shares on the nose only. *Experience has shown that plowshares hard-faced with Haynes Stellite rod will plow, on the average, 5 times longer than plowshares not hard-faced.*

These hints for hard-facing plowshares are typical of those which Haynes Stellite engineers and Linde service operators have available to help you get greater savings from hard-facing. Call on them, if you have hard-facing problems. There is no obligation.

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**Philleo, R. A.** (C), Pacific Railway Equip. Co., Box 397, Vernon Sta., Los Angeles, Calif.
**Powers, J. A.** (C), 4855 W. Jefferson Blvd., Los Angeles, Calif.
**Steele, E. R.** (F), 1017 W. San Fernando Rd., Burbank, Calif.
**Stoner, Eliot F.** (C), Pacific Railway Equip. Co., Box 397, Vernon Sta., Los Angeles, Calif.
**Thomas, Walter J.** (B), 7823 Crockett Blvd., Los Angeles, Calif.
**Wiebe, Alden H.** (D), 1920 W. 48th St., Los Angeles, Calif.
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**Golinick, A. J.** (C), P. O. Box 108, Balboa, Canal Zone.
**Hensley, Maurice N.** (F), 413 E. State St., Apt. 21, Milwaukee, Wisc.
**Keim, Lee J.** (C), 1560 S. 6th St., Milwaukee, Wisc.
**Matush, Milan A.** (C), Sta. F. Rt. 10, Box 285, Milwaukee, Wisc.
**Pollak, Stephen E.** (D), 418 E. Juneau Ave., Milwaukee, Wisc.
**Scorey, George** (C), 2106 E. Jarvis St., Milwaukee, Wisc.

### NEW YORK

**Charles, T.** (D), 441—40th St., Brooklyn, N. Y.
**Frazer, F. Taylor** (D), 20 W. Holly St., Cranford, N. J.
**Hasbrouck, Chas. L.** (D), 34-35—82nd St., Jackson Heights, N. Y.
**Higgins, Theodore R.** (C), American Inst. of Steel Constr., 101 Park Ave., New York, N. Y.
**Johnstone, R. A.** (B), 635—6th Ave., New York, N. Y.
**Mitchell, Raymond S.** (D), 36 Stewart Ave., Arlington, N. J.
**Niemie, T. J.** (D), 32 Water St., So. River, N. J.
**Thamme, E. P.** (C), 111 Elizabeth St., P. O. Box 242, Farmingdale, L. I., N. Y.
**White, Raymond E.** (B), Hemphill Schools, Inc., 3128 Queens Blvd., Long Island City, N. Y.

### NORTHERN NEW YORK

**Hannon, C. H.** (B), 100 Woodlawn Ave., Pittsfield, Mass.

### WESTERN NEW YORK

**Cobb, G. W.** (C), Welding Engrg. Sales Corp., 1 W. Genesee St., Buffalo, N. Y.
**Mattes, Frank J.** (C), Buffalo Tank Corp., Buffalo, N. Y.
**Oldman, Nelson E.** (B), Oldman Boiler Works, 32 Illinois St., Buffalo, N. Y.
**Paul, Caryl C.** (B), 37-43 Flohr Ave., Buffalo, N. Y.

### OKLAHOMA CITY

**Gamm, Warren G.** (F), 325 Cordell Hall, Stillwater, Okla.
**Moore, Billy** (F), 324 West St., Stillwater, Okla.
**Shaller, O. H.** (F), Redmoon Supply Co., Cheyenne, Okla.
**Thomas, Richard B.** (F), Box 22, Stillwater, Okla.

### PEORIA

**Borkler, Charles** (D), 142 Mt. Clair, Peoria, Ill.

### PHILADELPHIA

**Griffith, J. Earl** (D), Box 282, Kennett Square, Pa.

### PITTSBURGH

**Bissinger, J. A.** (C), R. D. 1, Sewickley, Pa.
**Crea, J. L.** (C), Dixon St., Midway, Pa.
**Dawson, A. J.** (B), Dravo Corp., Neville Island Br., Pittsburgh, Pa.
**Dickson, M. S.** (C), 325 Meadow Lane, Edgeworth, Sewickley, Pa.
**Duncan, Andrew** (C), 35 Hawley Ave., Bellevue, Pittsburgh, Pa.
**Gaiser, G. L.** (C), 110 Poplar Dr., So. Hills Br., Pittsburgh, Pa.
**Kiggins, William R.** (D), 219 So. Third St., Youngwood, Pa.
**Lindholm, John** (C), 7035 Flaccus Rd., Ben Avon, Pa.
**Martin, L. C.** (B), Homestead Steel Wks., Munhall, Pa.
**O'Laughlin, P. M.** (C), 1509 Vance Ave., Coraopolis, Pa.
**Schuyler, Thomas C.** (C), 406 Main St., Titusville, Pa.
**Streithof, C. P.** (C), 1414 Ridge Ave., Coraopolis, Pa.
**Willison, Ernest** (C), 611 Nevin Ave., Sewickley, Pa.

### ROCHESTER

**Wineck, Fred S.** (D), 1094 Hudson Ave., Rochester, N. Y.

### ST. LOUIS

**Lenz, Otto P.** (B), The Emerson Elec. Mfg. Co., 1824 Washington Ave., St. Louis, Mo.

### SAN FRANCISCO

**Spear, Robert D.** (C), Foster-Wheeler Corp., 74 New Montgomery St., San Francisco, Calif.
**Stettner, L. W.** (B), Victor Equip. Co., 844 Folsom St., San Francisco, Calif.

### SOUTH TEXAS

**Cargill, Clarence C.** (D), P. O. Box 2539, Houston, Texas.

### TULSA

**Clemmons, Al J.** (F), 1816 S. Olympia, Tulsa, Okla.
**Davis, James B.** (B), Tulsa Testing Lab., Box No. 2654, Tulsa, Okla.

### WASHINGTON, D. C.

**Adair, J. G.** (C), Interstate Commerce Commission, Washington, D. C.
**Laverty, C. Russell** (C), Bethlehem Steel Co., 702 American Security Bldg., Washington, D. C.
**Turner, Thomas L.** (C), Bethlehem Steel Co., 702 American Security Bldg., Washington, D. C.
**White, Lloyd Y.** (C), H. H. Robertson Co., 905 Washington Bldg., Washington D. C.

### WICHITA

**Schrock, J. E.** (D), Comanche County Highway Dept., Coldwater, Kan.

### YORK

**Delano, H. A.** (B), American Chain & Cable Co., York, Pa.
**Lashar, W. B., Jr.** (B), American Chain & Cable Co., E. Princess & Charles St., York, Pa.
**Silberger, M. E.** (B), 1531 Third Ave., York, Pa.

### YOUNGSTOWN

**Beck, Theodore** (C), 743 Glenwood Ave., Warren, Ohio.
**Coombs, Edwin C.** (D), 437 Forest St., N. E., Warren, Ohio.
**Fullenkamp, G. C.** (D), 148 Atlantic, N. E., Warren, Ohio.
**Fusselman, D. F.** (D), 915 Hunter St., N. W., Warren, Ohio.
**Jones, T. Embury** (C), The Oaks, R. D. 3, Warren, Ohio.
**Klingeman, William E.** (D), 212 Bonnie Brae, N. E., Warren, Ohio.
**Kudrich, John** (D), Federal Mach. & Welder Co., 212 Dana St., Warren, Ohio.
**Middlestead, Charles W.** (C), 773 Kenilworth S. E., Warren, Ohio.
**McCreery, Robt. D.** (D), 7 Elm St., Brecksville, Ohio.
**Pestrak, Walter** (D), 1305 Brighton Ave., Warren, Ohio.
**Schwartz, Wm. K.** (D), 896 Terra Alta St., N. E., Warren, Ohio.
**Shultz, John E.** (C), 212 Dana St., Warren, Ohio.
**Williams, Arthur L.** (C), 546 Hazelwood Ave. S. E., Warren, Ohio.
**Wise, Benjamin L.** (C), 377 Butler Rd., Warren, Ohio.
**Woodward, Foster R.** (C), Federal Mach. & Welder Co., Warren, Ohio.

### NOT IN SECTIONS

**Black, A. B.** (D), % Atlantic Gulf & Pacific Co., 77-79 Muelle de la Industria, Manila, Philippines.
**Bruestle, Chas. C.** (B), 1463 Talbot Ave., Jacksonville, Fla.
**Cogan, Howard C.** (B), National Elec. Welding Mach. Co., Bay City, Mich
**Duffy, J. H.** (C), Ohio River Sand Co., Brook & River Rd., Louisville, Ky.
**Eremp, G.** (B), Arc Engineering Supply Co., 25 Maddison St., Jeppe, Johannesburg, South Africa.
**Fisher, Simon** (B), National Elec. Welding Mach. Co., Bay City, Mich.
**Hoffman, C. Raymond** (C), Standard Oil Co. of Venezuela, % Drilling Dept., Socororo No. 1, Venezuela, South America.
**Jenkins, Don S.** (D), 352 W. 5th North St., Salt Lake City, Utah.
**Kaunitz, Clyde F.** (B), National Elec. Welding Mach. Co., Bay City, Mich.
**Miller, E. W.** (C), Pioneer Auto Body & Welding Shop, Charlevoix, Mich.
**Noe, Thomas P., Jr.** (B), Carolina Steel & Iron Co., Greensboro, N. C.
**Ogden, R. H.** (C), Aladdin Rod & Flux Mfg. Co., 927 Ballard, S. E., Grand Rapids, Mich.
**Riley, Joe W.** (C), Iowa Mfg. Co., Cedar Rapids, Iowa.
**Shearer, Charles E.** (B), National Elec. Welding Mach. Co., Bay City, Mich
**Smith, Edward C.** (B), National Elec. Welding Mach. Co., Bay City, Mich.
**Stovern, Ingram** (C), 720 Clara Ave., Sheboygan, Wisc.
**Wallace, W. L.** (A), Manitowoc Shipbuilding Co., Manitowoc, Wisc.
**Weisbecker, T. R.** (C), 1210 East Ave. So., La Crosse, Wisc.
**Zimmermann, Oliver E.** (B), % Luis Menchaca Y Cia. Ltd. Casilla 1081, Santiago, Chile, South America.

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# New Sustaining Members

**Dravo Corporation, Neville Island Station, Pittsburgh, Pennsylvania.** Designers, fabricators, builders of barges, cranes, towboats, tugs, car floats, dump scows, dredges, derrick boats, material handling installations, steel floating and terminal equipment, ore bridges, mine cars; fabricator of pipe, structural steel, reinforcing steel, pneumatic caisson; also, producers and shippers of sand, gravel, ready mixed concrete; contractors for locks, dams, bridge piers, retaining walls, shafts, tunnels, industrial foundations, pump houses, heavy machinery sales and installations.

**The Electroloy Company, Inc., 1600 Seaview Avenue, Bridgeport, Connecticut,** with offices in the various manufacturing centers, are producers of all types of Resistance Welding Electrodes. Their products include many high-strength, high-conductivity copper base alloys, developed especially for the resistance welding industry. These alloys are supplied either in rough form as forgings, castings and rolled bars, or as finished electrodes for any type of resistance welding. The Company maintains a program of engineering and developmental research in the resistance welding field.

## WIDE-VISION GOGGLE

A full 150° effective range of vision is offered in the new, improved No. 220 Wide-Vision Goggle illustrated, one of the latest developments of the Chicago Eye Shield Company, 2360 Dept. C, Warren Boulevard, Chicago. This is said by the manufacturer to be tantamount to obtaining the widest practical amount of

working vision through the medium of lens-embodying, eye-protective devices. Hardened safety lenses provide maximum protection against severe impacts. Both lenses are easy to renew, by sliding them through the outer side of each eye-cup, and inserting the new replacement.

## WELDED BUILDING

The Howard Flint Ink Company of Houston is building a new factory building 100 ft. x 230 ft., one story, no field welding. Qualification of welders and the inspection of all construction being handled by Industrial Welding & Testing Lab. of Houston, Texas.

## BROCHURE ON $200,000 AWARD PROGRAM

*48-Page Document, in Preparation Over 12 Months, Gives Object and Purpose of 2½-Year Industrial Study Program and Cites Terms and Conditions Upon Which 458 Awards Are To Be Made*

"$200,000 Industrial Progress Award Program" is the title of a 48-page brochure just published by The James F. Lincoln Arc Welding Foundation, Cleveland, Ohio.

Official document of the 2½-year Industrial Progress Program, announced by the Foundation in January, the brochure is the culmination of more than a year of planning and development, by trustees and officers of the Foundation in collaboration with many other individuals to formulate a program of industrial study and research which would be productive of greatest possible benefit, not only to industry but to society at large. Embodying features which reflect the experience of the Foundation in conducting a previous industrial award program (1937–1938) in which 382 significant studies received $200,000, the brochure also incorporates valuable comments and suggestions of educators, economists, sociologists, as well as executives and others representing all branches of the industrial field.

Following the "Foreword," the brochure announces the purpose of the Progress Program, indicates the Program's wide scope and lists the 12 classifications and 46 divisions for participation which cover every conceivable branch of the industrial field. Then follows a definition of the subject matter of studies in the Progress Program, a table and chart of the 458 awards, particulars concerning eligibility for participation (indicating that virtually anyone may participate), subject matter, factors for judging papers, together with many suggestions of practical assistance to those who participate. A point stressed in the brochure is the form in which subject matter is to be presented. "Style of presentation, such as expensive or elaborate bindings, etc., will have no bearing on the rating of papers."

Approximately half the brochure is devoted to listings and illustrations of typical subjects for study in the 12 classifications and 46 divisions of the Progress Program. This section is believed the only directory available which lists products and structures and work typical of every field of industry. The lists were compiled from literally hundreds of individual sources and represent many months of exacting compilation and arrangement.

Printed in Bookman type on 8½ x 11 inch dull coated clear white paper, with self-contained gold-embossed cover, the brochure "$200,000 Industrial Progress Award Program," may be obtained gratis by all individuals interested in participation in the Program themselves or by executives and others who desire to encourage participation on the part of their employees, friends or associates.

Requests for the brochure should be addressed: Secretary, The James F. Lincoln Arc Welding Foundation, Cleveland, Ohio.

## G-E GAGE

A new low-priced fillet-weld gage has been developed by General Electric Co. to meet a long-felt need on the part of welding inspectors and operators for a fast, accurate means of checking the size of fillet welds on jobs which have to meet rigid specifications. The new device, which slides readily into a shirt or trouser pocket, is of extremely simple construction, consisting of three stainless-steel stampings held together by a bolt and a knurled thumb-nut. Either convex, concave or Standard fillets can be checked merely by fitting the edge of the gage flush against the work so that the indicating portion of the gage rests on the weld bead. The gage can be used on fillets of the following sizes: 5/16 in., 3/8 in., 1/4 in., 5/16 in., 7/16 in., 1/2 in. and 5/8 in. These sizes are clearly marked in black on the gage.

## EMPLOYMENT SERVICE BULLETIN

### SERVICES AVAILABLE

A-340. Young engineer desires position. Graduate Mechanical Engineering, University of Idaho. Interested in welding construction and design. Know how to weld. Designed welding on wind tunnel. Can furnish references.

A-341. Twelve years' experience in cutting, machine cutting, layout and welding all metals either by Electric Arc or Oxy-acetylene. Eight years' experience in street railway maintenance of way including high carbon rail welding and welding of manganese frogs and switches. Three years' general shop manufacture and repair of electric motors, generators, controls, etc. Capable of supervisory position. Prefer Southwest location. Married; 35 years of age. Best of references.

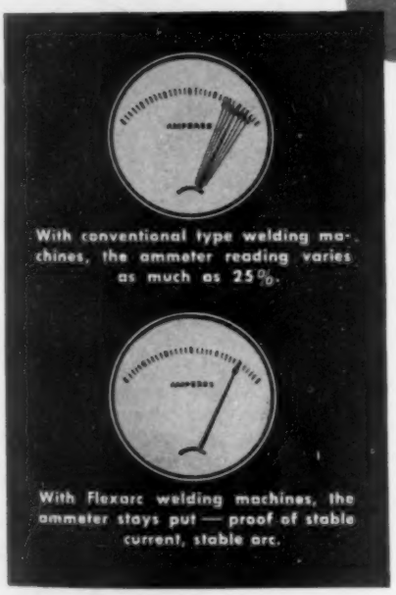
A-342. Welding-Metallurgist. Want work—development and improvement shop welding methods or shop job leading to responsibility as production experience is acquired. Age 26. Five years on development and laboratory, technical service, monel, nickel, inconel, cast iron, hard surfacing—rods, techniques, methods. Associated metallography, physical testing, heat treating, actual welding gas and arc.

A-343. Welder and draftsman, 25, high school graduate with seven years' experience in arc and gas welding, desires position with opportunity for advancement.

A-344. Welder. Took courses on butt welding, tack welding and vertical welding.

A-345. Welder. Have had 100 hours of actual practicing of gas and arc welding in a school course. Age 23, ambitious and can produce references. Hard and willing worker.

MAKE ANY TEST YOU LIKE! THE ANSWER IS THE FLEXARC WITH JUST ONE PRE-SET CONTROL
BEFORE YOU BUY ANY WELDER
Make the
AMMETER TEST


With conventional type welding machines, the ammeter reading varies as much as 25%.
With Flexarc welding machines, the ammeter stays put — proof of stable current, stable arc.

## STABLE NEEDLE PROVES *Flexarc's* SMOOTHER, STABLE ARC

It's the steady flow of current from your welder that gives the steady flow of metal from the electrode. In buying welding machines make sure that the flow of current is steady — put an ammeter on the working end of the cable. Compare the reading as shown on the Flexarc with the reading shown on any other type of welder.

Note how rock-steady the needle stays when the Flexarc is in operation. Compare it with the needle variations on conventional type welders — the proof is there, proof you can't afford to overlook if you want to get the most welding done for your money.

You can rent a Flexarc — easy terms. Send the coupon for details. Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.

J-20915

# Westinghouse Flexarc Welders

*Show Us!*

☐ Send us the facts about Flexarc welders, including details of your rental plan.

Name_____

Company_____

Address_____

City_____

## LAKE SHORE SECTION

The Lake Shore Section with headquarters at Manitowoc, Wisconsin, was organized on the evening of February 26, 1940. Mr. K. L. Hansen, District Vice-President of the AMERICAN WELDING SOCIETY, gave a very interesting talk on this occasion. The following were elected to office: Albert W. Wiemann, Plant Engineer, Armour Leather Co., Sheboygan, Wisconsin, Chairman; L. V. Olson, Manitowoc Shipbuilding Co., Vice-Chairman; Robert E. King, Manitowoc Shipbuilding Co., Secretary-Treasurer.

## ALL-WELDED TUGS

The front cover illustrates one of two new all-welded Diesel propelled tugs designed by The Pusey and Jones Corporation, Wilmington, Delaware, with a view to obtaining a smart, sea-going appearance through a form of styling not hitherto attempted on this class of coastwise vessel.

The tugs themselves embody a new type of patented hull form and have a special nozzle around the propeller; the former allowing a full ship speed of 12 miles an hour with virtually no wave disturbance and the latter a 47½% increase in direct towing pull; that is, the equivalent of 502 hp. from a 320 hp. engine.

## STEEL MEETING

Over one thousand steel mill executives and operating engineers are expected to attend the Annual Spring Conference of the Association of Iron and Steel Engineers, which will be held in the Hotel Netherland Plaza in Cincinnati, Ohio, on Monday and Tuesday, April 1 and 2, 1940.

Technical sessions covering a wide variety of subjects on the operation of steel mills will be presented on Monday, April 1st, in the morning and evening. The morning session will have the following papers: "Electrical Features of the Armco Slabbing Mill," by A. F. Kenyon, Steel Mill Engineer, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania; "Factors to Be Considered in Modernizing Existing Rolling Mills," by C. H. Hunt, Consulting Engineer, Pittsburgh, Pennsylvania; "Strip Mill Finishing Equipment," by D. A. McArthur, Chief Engineer, Wean Engineering Company, Warren, Ohio; and "Ward-Leonard Control for Strip Mill Auxiliary Drives," by E. S. Murrah and H. W. Poole, Steel Mill Section, Industrial Department, General Electric Company, Schenectady, New York. The evening session will have two papers on the following subjects: "Improvements in Open Hearth Design and Operation," by L. F. Reinartz, Manager, Middletown Division, American Rolling Mill Company, Middletown, Ohio; and "Problems in the Operation of Wide Strip Mills," by G. D. Tranter, General Superintendent, American Rolling Mill Company, Middletown, Ohio.

On Monday afternoon an inspection trip will be conducted to the Andrews Steel Company in Newport, Kentucky. This plant includes, among its other facilities for steel making, an open-hearth department, a 36-in. blooming mill and a 24-in. semi-continuous bar mill. The semi-continuous bar mill has been recently modernized and presents some interesting and unusual features.

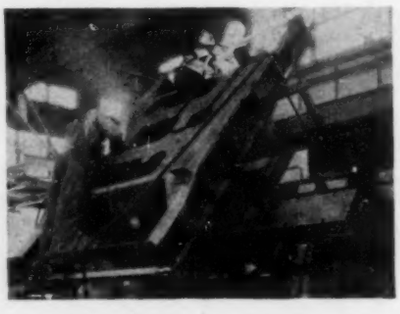
On Tuesday, April 2nd, the entire day will be utilized in the inspection of the entire properties of the American Rolling Mill Company at the Hamilton and Middletown plants. This company pioneered in the development of the modern wide strip mill which revolutionized the production of sheet and strip. An unusual feature of these plants is the fact that hot metal is transported a distance of fourteen miles between the blast furnace and open hearths. This is believed to be the longest movement of hot metal in the world. The hot strip mill at the Middletown plant has been recently rearranged and modernized, at the present having a capacity of 65,000 net tons per month.

## FOOTE MINERAL PLANT

To maintain a continued level of efficiency and service at stable prices, the Foote Mineral Company of Philadelphia have just completed a three-story fireproof grinding unit and warehouse. Located at Queen Street and Mermaid Lane, this new plant has been equipped with every facility for the rapid movement of large tonnages of ores including a new railroad siding and truck platform. The increased capacity of the mill and additional warehouse space will enable the Foote Mineral Company to stock greater quantities of raw materials and provides more space for storage of goods under contract. The new grinding unit is designed to produce a greater uniformity of close granulation as well as a higher percentage of recovery. Particular emphasis has been placed on these two points in an effort to offset the price rise and scarcity of raw materials by improved efficiency.

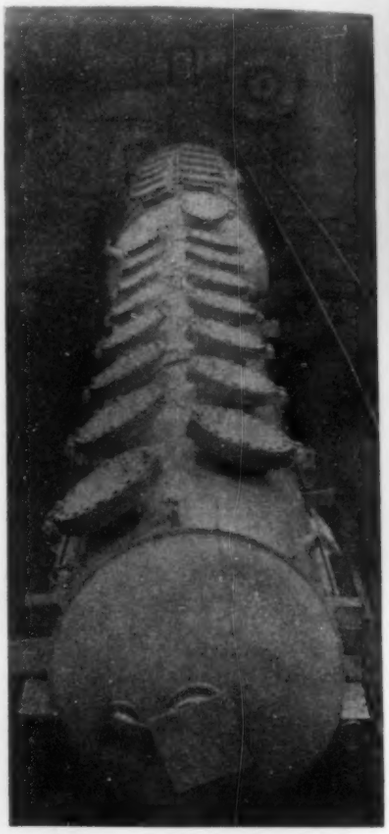
## CRAWLER SHOVEL

The illustration below taken in the Chicago plant of Link-Belt Speeder Corp., 301 W. Pershing Road, illustrates the welding of lower frame for a crawler shovel, dragline, crane of the new Speed-o-Matic "300" Series.



## STABILIZER TOWER

The illustration below was furnished through the courtesy of the Petroleum Iron Works Company, Sharon, Pa. The vessel was X-rayed and stress relieved. It is a Stabilizer Tower 7 ft. 6 in./5 ft. 0 in. I.D. x 62 ft. 6 in. high, 7 ft. 6 in. section $^{15}/_{16}$ in.—5 ft. section $^{11}/_{16}$ in.

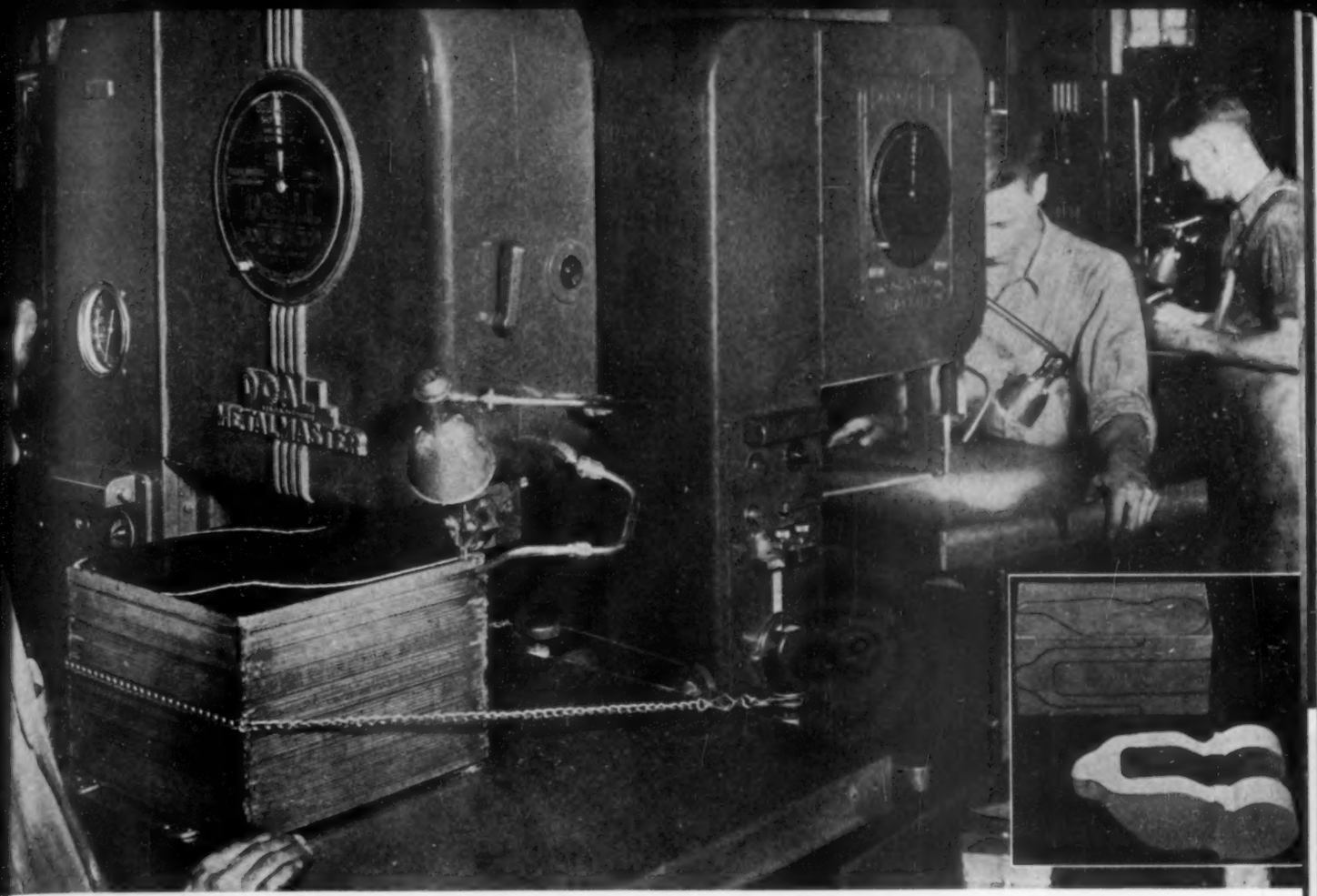


## CASTOLIN

A new welding material, named Castolin, has just been introduced on the American market. It comes in a variety of alloys and fluxes for oxyacetylene welding. Due to the low temperatures at which welding can be made with Castolin alloys, overheating and subsequent warping of welded parts is avoided; stresses are eliminated. Alloys for the steel, aluminum, brass and bronze industries are now available.

Outstanding among Castolin alloys are:

Castolin 190 for welding of aluminum and its alloys, even in the form of very thin sheets. Castolin 190 flows at 930° F. and has great tensile strength (35,000 lbs./sq. in.) and durability. A welding alloy very helpful particularly to the aviation and automobile industries. Castolin 185, also called Bronzochrome, for building up on steel, cast iron, copper, brass, bronze, etc. This alloy flows poreless at 750° F. Though of a hardness of 230 Brinell, it can easily be machined and is an ideal material for repairing broken or worn out parts of machinery.




*DOALL contour machines set up for (left to right) cutting, filing and polishing. Inset: poppet lever sawed out of steel block and filed by DOALL. Courtesy Continental Machines, Inc., Minneapolis, Minnesota.*

# A GOOD IDEA ON PAPER BECOMES A WHIZ IN STEEL

● Last decade's development of alloys such as chromium and molybdenum made possible saw blades as narrow as 1/16-inch for cutting metal . . . gave promise of a gala comeback for the band saw—star of the lumber show at the World's Fair in '98. The idea of these new, tough, slender saws was good—on paper. How to make them actual cost cutters for the average shop was the problem.

For six years, the metal-cutting band saw went through the development mill. One improvement after another came until finally it seemed that the ideal model had been attained. It was made of seasoned castings. It worked perfectly. But it was still in the luxury class.

Then Doctors of Design went to work on the problem with *"Shield-Arc"* welded steel construction. They developed a rigid, strong, light-weight machine that produced more uniform work at less cost. (*The welded steel "Model V-16," does three times as much work as the "Model J" it replaces.*)

Result: This versatile "contouring" machine, now profitable for the average shop, is revolutionizing many machining practices for lower costs. A good idea on paper becomes a whiz in steel . . . and in sales.

*"Shield-Arc"* welding has turned good ideas into profits in thousands of similar cases—in manufacturing, construction and maintenance. Try this method of uniting design ingenuity with superior materials and see how it makes *your* products ***stronger, more rigid, better looking*** with savings in weight, time and money.* Counsel of experienced Lincoln engineers is yours for the asking. Phone the nearest Lincoln office or write THE LINCOLN ELECTRIC COMPANY, Dept. DD-6, Cleveland, Ohio. Largest Manufacturers of Arc Welding Equipment in the World.

## LINCOLN "SHIELD-ARC" WELDING

***Unites design ingenuity with superior structural materials for progress.***

**THEY BOTH HAVE IT**—Both *"Shield-Arc"* and *"Shield-Arc Jr."* Welders have Continuous Self-Indicating "Job Selector" (assuring the right TYPE of arc) and Current Control (assuring the right AMPERAGE) for lowest costs on every job. Get free bulletin on these New Lincoln Welders.

* **FOR EXAMPLE.** Standard steel shapes and pressed steel parts simplify production of DOALL machines. Eliminate patterns and expensive time-consuming steps. Accurate assembly by welding limits machining operations to a quick grinding. Result: Faster production. Lower costs.

**FASTER FILLETS.** Users of the new "Fleetweld 8" report 10% to 30% faster fillet welding with this smooth-flowing Lincoln Electrode. For positioned and non-positioned flat fillets. Ask for free procedure bulletin.

Other alloys available are No. 14 for cast iron, binds at 900° F. Tensile strength 47,000 to 51,000 lbs./sq. in.

The above Castolin alloys and others are described in Pamphlet C-33 issued by Park Sales Co., 3 Park Place, New York City.

## NATIONAL METAL CONGRESS

Floor plans for the 1940 National Metal Congress and Exposition have just been mailed to previous exhibitors in the shows, with requests for space reservations. The Exposition will be held in Cleveland from October 21st to 25th in that city's Public Auditorium. Former exhibitors are requested to make three choices of space locations, with deadline for receipt of requests set at Saturday, April 6th. Upon receipt of space reservations the Assignment Committee of the National Metal Congress will make final allocations.

The 1939 show in Chicago, upon being broken down as to attendance, showed that over 90% of the registrations included presidents, vice-presidents, treasurers, engineers, purchasing agents, metallurgists, managers and superintendents of various companies.

The National Metal Congress is held simultaneously during the five days with the National Metal Exposition, and participated in by the American Society for Metals, the AMERICAN WELDING SOCIETY, the Wire Association, and the Iron and Steel Division and the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers.

According to Wm. H. Eisenman, managing director of the National Metal Congress, facilities at the Cleveland Public Auditorium will help in making possible one of the outstanding meetings in the metals field.

"Year after year," according to Mr. Eisenman, "the outstanding technical program greatly adds in the drawing of interested persons to the Exposition. The program for Cleveland is still in the formative stage and is being prepared in cooperation with four of the major technical societies in the United States."

## CHAMPION ELECTRODES

The Champion Rivet Company, Cleveland, are pleased to announce they have just concluded arrangements with the United States Steel Export Company, 30 Church St., New York City, to handle the exclusive sale of their Champion Welding Electrodes for export throughout the world.

## WELDING HIGH PRESSURE PIPING

Below are given some illustrations furnished us through the courtesy of the Midwest Piping and Supply Co. Inc., St. Louis, Mo.

Figure 1 is a view of the Layout Tables in the St. Louis Plant. Welded assemblies are cut, fitted up and then tacked preparatory to welding.

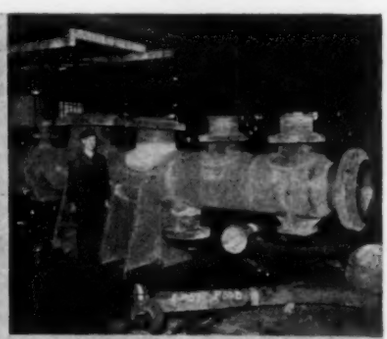
Figure 2 is 24-inch O.D. Reinforced Welded Header for large utility company. Used for 450 lb. working pressure and 750° total temperature. This view shows the header when taken from the annealing furnace and before cleaning.

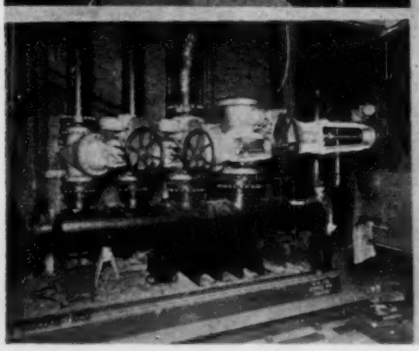
The same header during installation is shown in Fig. 3. Note the anchor base and roller supports for expansion are welded integral with header.

Figure 4 shows the same 24-inch header after testing and ready for shipment to the customer.

Fig. 1

Fig. 2





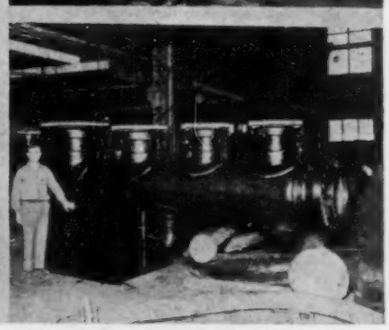


Fig. 3

Fig. 4

## DRILLING BIT

The illustrations shown below are both of welding operations on the Reed Welded-in Blade Drilling Bit. In the first picture the welders are welding the inserts into the

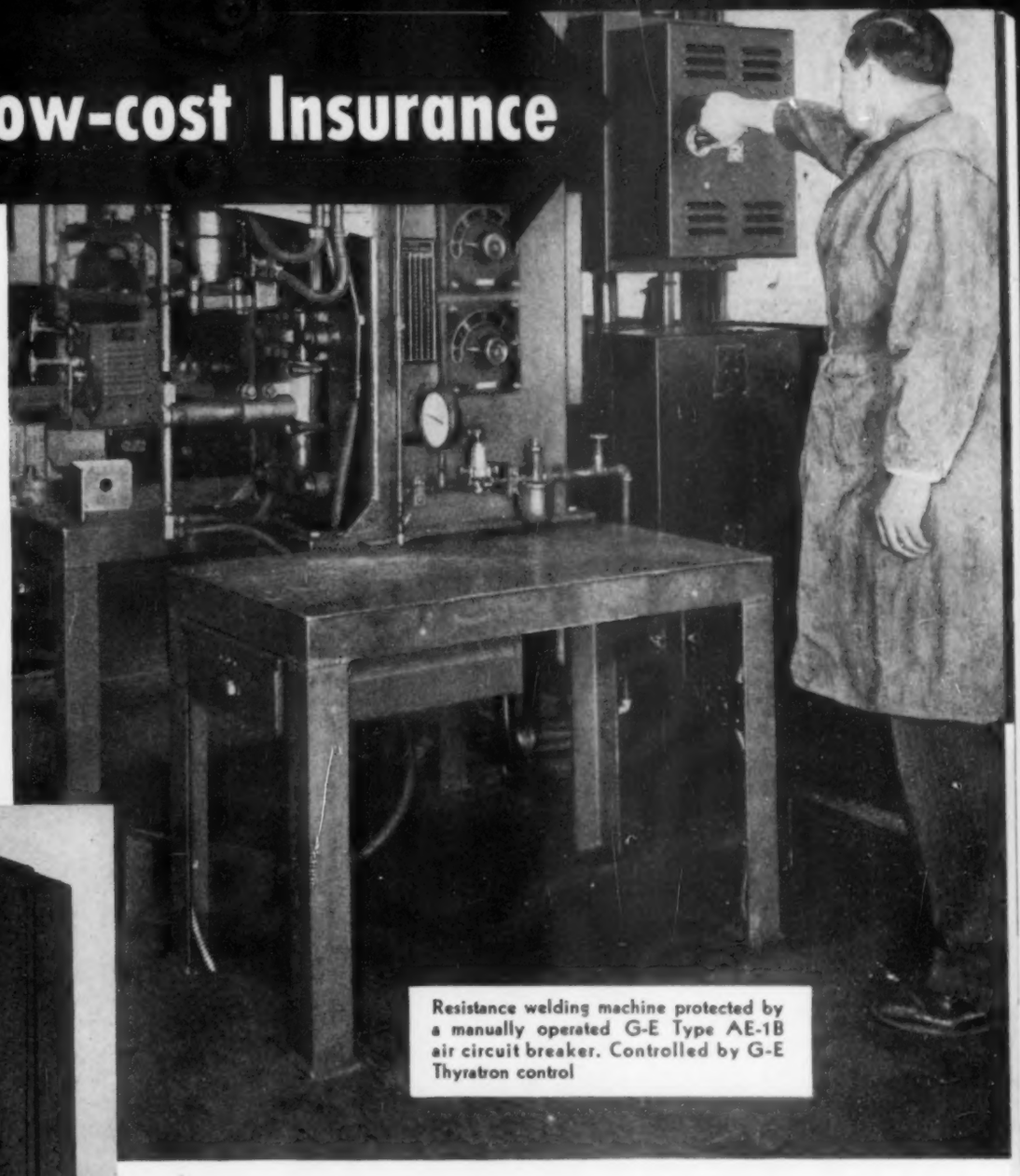
replaceable blades. In the second, the blades are being welded into the bit head after being carefully aligned and positioned by accurate jigs and fixtures.

## SEED STORAGE TANK

Above is shown an illustration furnished us through the courtesy of the J. B. Klein Iron & Foundry Company, Oklahoma City, Okla., of an all-welded cottonseed storage tank which was erected by them for Vernon Cotton Oil Company, Vernon, Texas. This storage tank is 80 feet in diameter and 124 feet high.

# 's Mighty Low-cost Insurance

## *Protect* Your Resistance-welding Machines with G-E Air Circuit Breakers



Resistance welding machine protected by a manually operated G-E Type AE-1B air circuit breaker. Controlled by G-E Thyratron control

Manually operated AE-1 air circuit breakers are reclosed by merely flipping the operating handle—no parts to replace

FOR a small fraction of the cost of your welding machine you get continuous, high-speed production, and protection for the machine and its operator. That's something worth thinking about.

When a G-E air breaker trips out, you need only push a button or flip a handle to restore service. But the real advantage is that it will trip out only when it should do so.

That's because G-E breakers are equipped with adjustable instantaneous overcurrent trips which can easily be set from the lowest to the highest current values of the breaker. The magnetic trips come into action only when the current exceeds the predetermined setting.

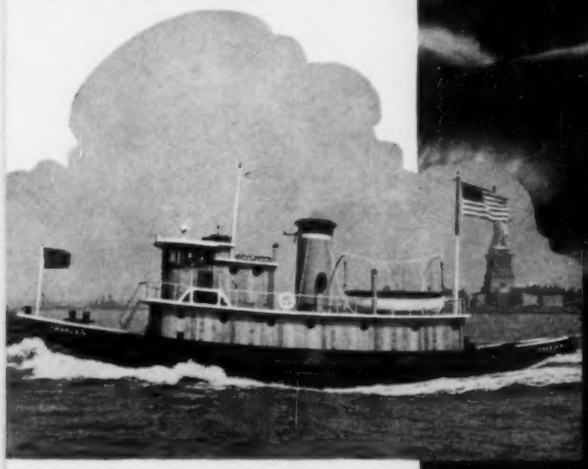
Should a short circuit occur, the breaker opens instantly, and the famous G-E "arc quencher" snuffs out the arc before your watch can tick twice.

These are only a few of the reasons why welding engineers all over the country are more and more using G-E Type AE-1 air circuit breakers. Ask your G-E representative for information about these breakers, or write General Electric, Schenectady, N. Y.

**GENERAL ELECTRIC**

890-83

Easy to use, Vertex Electrodes provided high speed work in the construction of this all welded tug, built by Ira Bushey & Sons Co., Brooklyn, N. Y.



# SET UP YOUR MACHINES AND STEP UP PRODUCTION with MUREX

# VERTEX

In building portable ... and other oil field ... fabricators such as ... chine & Supply Co., ... City, find Vertex ... to use.

## THE ALL-POSITION REVERSE POLARITY ELECTRODE THAT TAKES MORE CURRENT AND SPATTERS LESS

Neat appearance of welds made with Vertex lends additional sales appeal to products like this welded shovel, produced by Hanson Clutch & Machinery Co., Toledo, O.

*Investigate Thermit Welding, too—in use since 1902 for heavy repair work, crankshafts, etc.*

You can speed up your welding with Murex Vertex electrodes and still get the sort of sound, clean deposits that enhance the appearance of any welded structure.

Welders, too, like the way this rod performs; its soft arc action, even at the top of the current range; the ease with which it handles in the vertical and overhead positions; the readily removed slag and small amount of spatter.

Investigate Murex Vertex for structural or marine applications, for pipe welding, or wherever a reverse polarity electrode is required and the work cannot be positioned. Write for full information, and ask to have one of our welding engineers call to demonstrate Murex Electrodes on your type of work.

**METAL & THERMIT CORPORATION, 120 BROADWAY, NEW YORK, N. Y.**

Albany • Chicago • Pittsburgh • So. San Francisco • Toronto

*"Murex Electrodes—Thermit Welding—Thermit Metals & Alloys."*

MUREX HEAVY COATED Electrodes

A COMPLETE LINE FOR EVERY WELDING APPLICATION